The Book of Trades

John Russell Gubbins.

(c. 1860)

J. Russell Gubbins
London April 1874

THE

BOOK OF TRADES

PLATE 16.—POTTERY, p. 217—ETRUSCAN VASE.

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BOOK OF TRADES

A

CIRCLE OF THE ARTS AND MANUFACTURES

ADAPTED FOR

SCHOOLS, COLLEGES, AND FAMILIES

BY

JAMES WYLDE

AUTHOR OF THE "[illegible]" "[illegible]" "[illegible]" "SHELLS AND THEIR INHABITANTS," EDITOR OF THE IMPERIAL OCTAVO EDITION OF THE "CIRCLE OF THE SCIENCES," "THE BEAUTY OF THE HEAVENS," [illegible]

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PREFACE.

THERE are few matters which present greater difficulty to parents and teachers than the selection of books for young people. It is a trite and true saying, that "it is impossible to put old heads on young shoulders;" and, fortunately, the day is now past, although not forgotten, when learned treatises, on any and every subject, written in a harsh and technical style, were considered as proper for "first books." How many youths have become disgusted with study by such injudicious selections, and the ranks of duncedom recruited with those who, under more careful training, might have proved the pride of the school!

The difficulty in getting young persons to interest themselves with any subject may be readily or patiently overcome by consulting their taste, "genius" (certainly a most deceptive term), and their natural disposition. Young people always prefer "doing" to "thinking;" and hence it generally happens that, if we can employ their bodies, the mind may be deceived or seduced into its work, and so its powers may gradually, but surely, be called out.

But if we cannot always select subjects which can be actively engaged in—although we cannot make boys manufacturers, artizans, engineers, and so on—still, if we describe those occupations in a manner that leads the mind to understand the practical part of each branch of industry, we shall make them *think.* No matter whether we pass through the crowded town or the quiet village, a tradesman at work at his calling is sure to attract a crowd of idle boys; and the chances are that each gathers an idea, takes it home, ponders over it, and so gathers, perchance, the raw material of a Newton, a Watt, or a Stephenson. The child is the father of the man, and germs in juvenile minds have often produced fruit which has startled and revolutionized the world.

To catch the eye, to engage the fancy, to interest and instruct the young mind, by plain description free from technicality, and by suggesting simple methods of trying experiments, and following practically, at home, some of the subjects, the following pages, constituting the BOOK OF TRADES, are offered to the young themselves, or to them by the hands of their friends at home, and their teachers at school. The Author, at the early age of eleven, acquired an invincible taste for the study of such subjects as are here described. Sympathizing with his young readers in all their difficulties, from remembering his own, he has tried hard to put himself in their place; and whilst having seen and mixed with all he has described in a scientific and practical manner, he has endeavoured so to address his young readers as that they may not only understand, but gradually acquire a deep interest, and also amusement, as they read this little work. It has been so written as to permit it to be used, and it is hoped will recommend itself, as a *School Book*, for class and general reading. The table of contents sufficiently indicates the classification and range of subjects. Nearly all the leading trades and manufactures of civilized life have been dealt with, and information collateral with such subjects, or of general interest, is also afforded.

In conclusion, the author has only to express the hope that his chief object may be attained by the work now offered. His main desire has been to call out the *constructive*, and therefore *thinking* *faculties* of the young mind; and by affording amusing and interesting details of subjects constantly presenting themselves in daily life, to lead, step by step, from the playground and toy, to knowledge of a useful, practical, and therefore important character.

J. W.

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THE

BOOK OF TRADES.

CHAPTER I.

TRADES CONNECTED WITH CLOTHING.

We need scarcely remind our young readers that the kind of clothing required in different countries varies very much. For example, in Greenland and the Northern parts of Europe and Asia, where the snow lies almost constantly on the ground for the whole year, the skins of animals are chiefly used by the natives, and by persons occasionally travelling there. The animals, indeed, are clothed differently to those that we find in warmer climates; for they nearly all possess a thick long fur, which keeps them warm despite the intense cold and long winter, during which the sun never rises for many months. In countries like our own, again, we have to change our clothing with the season. Thus, in winter, woollen and fur articles of dress are used; whilst as summer approaches we lay aside these warm garments, and prefer such as are made of lighter material—say of cotton, linen, &c. If we go still further southward, as far as Africa and India, we shall find the natives scarcely clothed at all; for not only is the warmth of the air much greater than ours, but there is so little change in the heat throughout the year, that light clothing can be safely worn in all seasons. For this reason, the natives of India chiefly employ cotton for their dress; and an immense quantity of that material is grown and spun by them, besides the cloth that we send from Britain in the form of printed calico, which they largely purchase.

Before describing the different trades on which we depend for our clothing, we may properly answer the questions—Why is one kind of dress warmer than another? Why do inhabitants of cold countries use furs and skins of animals? and so on. The question is very easily answered, and may be understood by even a child. If we place one hand on a piece of metal—as for instance the handle of a door—and the other on a shawl, or any article of dress, we shall find that the metal will feel cold to the touch, whilst the shawl, &c., will feel comparatively warm. This happens because the metal quickly *carries away* or *conducts* the heat from the hand, whilst the shawl does so very slowly. Another instance of a similar kind is found in a metal tea-pot with a wooden or ivory handle. If the pot be filled with hot water, it will burn the fingers when touched, whilst the handle is quite cool; for the latter carries or conducts the heat slowly to the fingers, whilst the metal does so very rapidly. The metal is a good, and the wood or ivory a bad *conductor* of heat.

Now this very principle is always followed by us in choosing our clothing. In winter we choose fur skins or woollen articles, because they conduct heat very slowly from our bodies; in summer we prefer cotton or other light material, because we desire to part with the heat of our bodies. We may thus keep up any moderate degree of warmth by selecting materials for each season or climate, keeping in mind the different power which each has of retaining or allowing the escape of heat. It will be well for our readers to bear this in mind, for nearly every trade which has to do with clothing is more or less influenced by the principle we have thus briefly explained.

We may now glance, by way of introduction to our future pages, at some of the sources whence our clothing is supplied, or more properly, perhaps, we should say, the materials of which our clothing is made.

From animals, as the polar bear, seal, Arctic fox, mink, sable, beaver, hare, rabbit, &c., our furs are obtained. The sheep, and some species of goat afford us wool. The kid, chamois, and other species of goat also give us skins, of which gloves are made; dog and rat skins are also largely used for the same purpose. The ox, sheep, goat, horse, and some other animals afford skins, which, after tanning, produce leather, used for making shoes and boots. Even the worm is of value to us, for to two or three species of this creature we are indebted for the most costly dress—namely, silk.

Plants equally afford us materials for clothing. In Madagascar and many of the islands of the Pacific Ocean the natives use the bark of trees beaten out into cloth by means of mallets. This material is called Tapa cloth, and it is often beautifully ornamented by being dyed of different colours.

The cotton, flax, and hemp plants afford the materials from which the fibres take the same name. Calico, used for making shirts, ladies' dresses, &c., is woven from cotton; whilst linen is made from flax and hemp. Some kinds of nettle can be made to produce a beautiful material, as good as the best cambric made from flax; and the finest lace which we make in this country is almost equalled by the unprepared bark of the lace-tree, a native of Jamaica. Beautiful collars, purses, and many other ornamental articles are made from this singular substance. Many kinds of grasses are also used in foreign countries, and the leaves of the pine-apple, banana, &c., also produce a fibre which makes garments as good as those we manufacture from flax in the form of linen.

From the willow, and the straw of wheat, ladies' bonnets are made. Other plants give wood used in dyeing; but we shall have to speak of all these again in their proper place, under the trades in which they are employed; and having thus given you a general idea of the different sources whence the materials of our clothing, &c., are drawn, we shall now proceed to explain how they are prepared so as to fit them for that purpose. Many that we have named are sent to us from foreign countries, and after arriving here they are sold to persons called "manufacturers," whose trade it is to spin, weave, or otherwise treat them that they may be ready for our immediate use, or that other manufacturers may use them as material for making the articles of their special business.

As one of the most important branches of trade in this country, we shall commence with that of the

COTTON SPINNER.

From a very early date, cotton has been employed as a material from which clothing is made. India, especially, has been long noted for the cotton cloth it has produced; and even in our time the Dacca muslin, spun from cotton without machinery of any kind, far surpasses in fineness that which we can make in England.

The cotton plant is grown in India, China, America, and the West India Islands. That produced in various parts of North and South America is highly prized for its fineness and long fibre; the Indian sorts being coarser and short, are chiefly used for common cloth. The plant is generally of a shrub-kind; and the flowers have a beautiful yellow, turning to a red colour. When these die away, a pod of about the size of an apple is formed. This contains the cotton, and, on bursting, it presents a downy substance enclosing some seeds. The cotton-pod, in fact, is the fruit of the plant, just as the apple is that of the tree which bears it.

When the pod is quite ripe, negroes are employed to pick it. They pass between the long rows of plants, and cast the cotton into bags hung round their necks. The cotton is then dried in a suitable place, and afterwards cleaned from the husk or outer coating and the seeds, by a machine called a "gin." This consists of two rollers, between which the cotton is drawn, whilst a comb of iron teeth pulls away the seeds. These are collected and in part used to produce plants for next year's growth; they also give a good oil for burning, on being pressed by means of heavy rollers. Mr. Whitney invented a machine which works by means of circular saws, and so separates the cotton from the seeds, instead of by the comb we have just named. His "gin" is largely used in America.

The cotton when thus cleansed is packed into bales, which are pressed by great force, so as to drive the wool into the smallest possible space: a hydraulic press is employed, which is driven by the force of water. By these means, cotton bales are formed weighing about 400 pounds each. The bales are then sent on board ships, and conveyed to this and other countries in Europe.

[illegible] pod [illegible] formed. It contains the cotton wool, [illegible] seeds [illegible]. The cotton pod, or nut, is the fruit of the plant, just as the apple is that of the [illegible] tree.

When the pod is fully ripe, [illegible] are employed to pick it. They pass between the long rows of plants, and [illegible] the cotton into bags hanging round their necks. The cotton is then dried in the sun, and afterwards cleared from the husk or outer [illegible], and the seeds by a machine called a gin. This consists of two rollers, between which the cotton [illegible] the bottom [illegible]

[illegible] of the burning [illegible] in any [illegible]. Mr. [illegible] have used a machine [illegible] by means of [illegible] from the seeds [illegible] we have just named [illegible]

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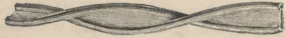


COTTON FIBRE MAGNIFIED.

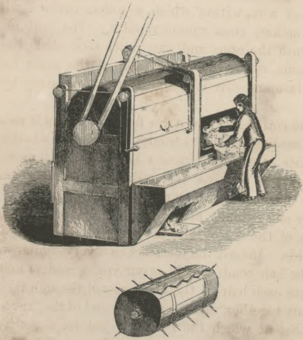


PLATE 1.—COTTON WILLOWING MACHINE, p. 7.

On arriving here they are sold to the cotton manufacturer, who, on receiving them at his factory, has them opened out. When the ropes are taken from the bale, the cotton, which has been so long pressed together, bursts open, and soon occupies much more space than when packed up. But it has to be opened out still further, and to be better cleaned before it can be used for spinning; different kinds are also mixed together, and this is done by "willowing" it. The "willow" consists of a cylinder or cage of wire, within which a roller, covered with iron spikes, runs round rapidly. The cotton is put into the cage, and the roller soon shakes out all seeds, opens the cotton, and at the same time the dust and dirt it contains are blown away by a fan.

The cotton has now a fine fleecy look, and is ready for "carding." The "carder," by which this is done, consists of a large cylinder covered with fine steel wires; and over its top, rollers, similarly covered with fine wires, revolve rapidly. The wires of both roller and cylinder nearly touch, and they drag each fibre of the cotton lengthways, and lay them side by side. Indeed, the teeth act in a very similar way to the hair comb, which, as our young readers know, makes each hair of the head, passed through it, lay evenly together. At the opposite end of the "carder" to that at which the cotton is put in, a roller is placed which receives the straightened fibres from the large cylinder, and from this the cotton is collected in a similar state to that of the wadding used to line ladies' dresses, furs, &c.

The sheet is then drawn through a ring or eye, and becomes stretched out into a long ribbon, about as wide as the wrist of a boy's hand; in this condition it is called a "sliver." These "slivers" are also drawn by means of rollers: they thus increase in length, but are gradually made thinner; and by being afterwards twisted slightly, become what is called a "roving."

The next step is that of spinning; and our young readers can easily imitate this process by drawing a little raw cotton, between the fingers and thumb, until all the fibres are straight: if one end of these fibres be then twisted by one hand, whilst they are held firmly by the other, they will overlap each other, and a round thread will be produced. The spinning frame does this in a more complete manner. It consists of a number of rollers placed at the back of the frame: through these rollers the "rovings," just named, are passed—one to each set of rollers—and from these the roving is passed to a "fly," which revolves rapidly round a bobbin placed between its arms. Now, as the roving leaves the rollers it becomes rapidly twisted, and passing through the fly it is wrapt round the bobbin, and becomes what is called "yarn." By another method the cotton is drawn out through the motion of the frame holding the spindles. As the frame moves from the rollers, the drawing is effected, but as the frame is made to

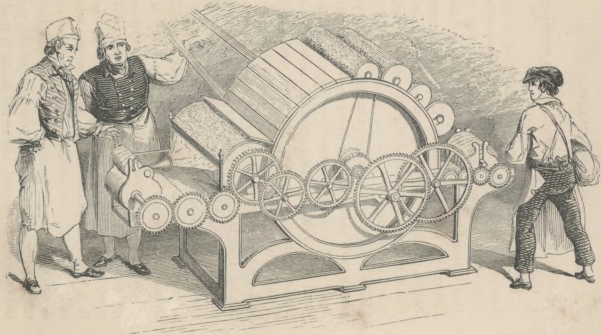


PLATE 2.—COTTON CARDING ENGINE, pp. 7, 8.

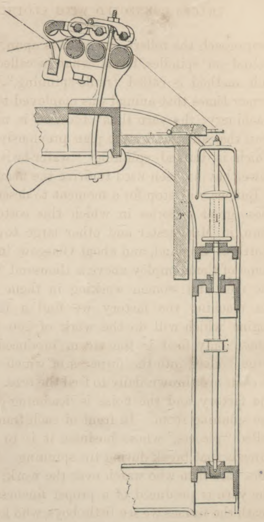


PLATE 3.—WATERTWIST SPINNING FRAME, p. 9.

re-approach the rollers, the yarn is spun, and being wound on spindles, forms what is called a "cop." This method is called "mule-spinning," because in former times that animal was employed to drive the machinery: the yarn thus produced is much softer than that afforded by the plan previously described, which is termed spinning "water-twist," water-power having been used to drive the machinery.

But we will stop for a moment to describe one of those great factories in which this cotton yarn is spun, in Manchester and other large towns in the North of England, and about Glasgow, in Scotland. Some of them employ above a thousand "hands," as the men and women working in them are called. On reaching the factory we find a large steam engine, which will do the work of 200 horses, but whose only food is the steam produced from six large boilers, into the furnaces of which many tons of coals are thrown daily to feed the fires. We enter the factory, and the noise is deafening on reaching the spinning room. In front of each frame are girls called "piecers," whose business it is to mend any threads that break during the spinning. The "spinners" are men who watch over the work, to see that the yarn is produced of a proper fineness. Underneath the frames we see little boys, who keep sweeping up the flue which flies from the cotton whilst it is being spun. These workers are never found careless, for any neglect would spoil the work and cause them to lose their wages, or perhaps their situation. The girls are neatly dressed, and look happy at their work, for they are exceedingly fond of indulging in singing whilst attending to it. It often happens that nearly the whole of a family are employed at the mill, to which they go at six in the morning, and work till six at night, having, however, about two hours allowed them for breakfast, dinner, and tea.

We must now return to the yarn, the spinning of which we have explained. In its present state it is termed "single," because it only consists of but one thread; and its uses in this form are chiefly confined, when coarse, to forming lamp and candlewick, fringes for bed curtains, and other minor purposes, with the exception of weaving, of which we shall shortly give a description, for by that process yarn becomes converted into calico or cotton cloth. "Sewing cotton" is made by twisting two or more threads together by means of a "doubler," which much resembles a spinning frame. Our young readers will readily understand this if they will untwist sewing thread, when they will at once separate each piece of yarn into the "single" state. "Mending cottons," used for mending stockings, are similarly made, but are only slightly twisted together, and so form a loose double thread. Crochet and other cottons are also produced by the doubling process.

In olden times all spinning was carried on by means of the spinning wheel—by women, generally speaking. A large wheel, worked by hand, turned round rapidly a smaller one, on which was a spindle. On this spindle a little cotton was fixed, and on the wheel being turned this became twisted. The cotton was supplied to the end of the yarn gradually, being held in the hand of the worker: indeed, at the present day, rope spinning is still carried on in the same way. The yarn was very uneven, and was produced so slowly that the weavers had often to wait a long time before they could get sufficient to commence work with. Now, however, the steam engine and the spinning frame produce any quantity required, and the ingenuity of Arkwright and Crompton, who invented or improved the spinning frame, and of James Watt, to whom we owe the steam engine, has produced the great trade in cotton, and enabled the poorest amongst us to obtain dresses that a hundred years ago were too expensive except for the rich to wear.

We shall now shortly describe the method of weaving the yarn into cloth commonly called "calico." It is said that this name is derived from Calicut, a town in India, where this kind of cotton cloth seems first to have been produced.

THE WEAVER.

In weaving, yarn is used for "warp" and "weft"—water-twist, or hard yarn, of which we have previously spoken, being used for the warp, and mule or soft twist for the weft. Our young friends can distinguish these two terms by remembering that the threads running *lengthways* of a piece of calico form the warp, and those which cross these, *widthways* of the calico, are the weft. We shall use these names in future, to save repeating their description.

The first process is that of preparing the yarn which is to be used for warp. As we have already explained, this is wound on to bobbins during the process of spinning. These bobbins are placed on spindles held in a suitable frame. The ends of each thread are brought together, and wound on to a large wheel or reel, the number of the threads depending on the width of the calico which has to be woven. As these threads eventually form the length of the cloth, the process now described is called "warping." When sufficient of the yarn has been wound on to this reel, or "warping mill," as it is commonly termed, the threads are wound off into a ball or bundle, and afterwards sized or stiffened by a paste of wheat or potato starch.

This warp is then wound on to a roller, and its threads are opened out from each other, so that they may be spread to the width of the cloth which is to be woven. Each thread is passed *alternately* through two "heddles," which much resemble a common hair-comb—a thread passing between each wire so as to keep them separate from each other during the process of weaving. The object of the heddles is to lift a whole row of warp threads by separate loops of string or wire at a time, each heddle bearing half of the number forming the warp: an open space is thus left between each set of warp threads as the weaving progresses. A shuttle, on which the weft yarn is wound, consists of a bobbin enclosed in a little frame; and as each heddle is raised or lowered, this shuttle is thrown by the weaver, and leaves a thread forming the weft or widthways of the cloth. These threads are pressed close to each other by means of a comb called a "reed," through which *all* the warp threads pass.

The process thus consists of three motions—one, that of separating the warp threads—another, that of throwing the weft between them—and the third, that of forcing this weft thread close to that preceding it. As the cloth is thus woven, it is wound onto a roller, until about twenty-seven yards have been produced, which is the average length of a "piece" of calico.

We have thus described what is called a "hand-loom," the motion to the whole being given by the feet of the weaver working the "heddles" with treadles like that of a knife-grinder's machine. His right hand throws the shuttle to form the weft. He sits in front of the frame or loom, the cloth being wound by his hand on to the roller, which is a little above his knees.

The hand-loom, in some form, has been in use for four thousand years, but it has been gradually improved as its defects were discovered. Weaving by it is, however, a slow process, and of late years has gone almost entirely out of use except for some kinds of wool-weaving, the manufacture of silk for dresses, shawls, and carpet making. It is now replaced in the cotton manufacture by the "power-loom," which is so called because it is entirely worked by steam, and requires no attention on the part of the weaver except to supply the shuttle with weft, and to piece a thread as it breaks. The power-loom is constructed on entirely the same principle as the hand-loom, but is much stronger, because it is moved by greater power than that of a man. In a calico weaving factory the looms are so arranged that one person can attend to two at a time, and the room often contains a large number of these, all working harmoniously together, and rapidly producing the calico of which ladies' dresses, shirts, &c., are made. The steam engine affords the motive power.

We have thus minutely described the process of cotton spinning and weaving, for the purpose of avoiding the necessity of repeating the processes when we have to speak of wool, flax, and silk. Woollen and flax yarn are spun, with some trifling exceptions, in the same manner; and blankets, woollen cloth of which coats, &c. are made, flannels, French merinoes, shawls, carpets, silk for ladies' dresses, pocket handkerchiefs, ribbons, &c., Irish linens, cambric, sheets for bed-clothes, and many similar articles, are all woven on machines nearly resembling the cotton-weaving frames or looms. Some exceptions to this we shall notice as we describe such articles hereafter.

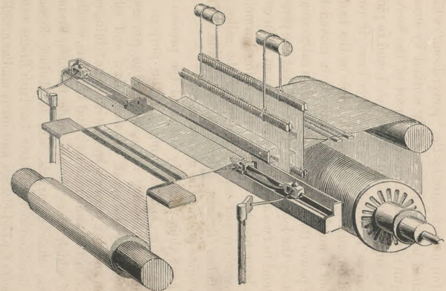


PLATE 4.—MECHANISM OF THE POWERLOOM, p. 14.

There are some trades connected with the cotton manufacture which we may describe under this head, for the process of preparing the material is dependent on some of those which we have already described.

Cotton Wadding, used by ladies to line dresses, furs, and for other purposes, is merely cotton taken from the carding engine in a sheet. It is received on a roller instead of being run through an eye, as mentioned in making slivers at page 8. The sheet varies in thickness according to the purpose for which it is intended; thus, there are sheets made twelve to one pound, two pounds, and so on in weight.

After the sheet is removed from the roller it is taken between folds of thick paper to the sizing room. In a large tub, some size, dissolved in hot water, is beaten into a froth by a birch-broom; and the sizer, dexterously taking a portion of this froth, by means of a long brush made of camel's hair, spreads it on one side of the wadding. This is then hung up to dry, and when the rough edges are removed, it is packed up in bundles of twelve sheets, and is ready for use. The coloured waddings are produced by first dyeing the cotton, and afterwards sizing them with size already dyed of the same colour. In making waddings, the waste of the cotton-spinner is chiefly employed; but for the best articles some raw cotton is also used. Bleached cotton is prepared for the best white waddings.

Cotton Wool.—This simply consists of the carded cotton just as it is taken from the carding engine. The common sorts are used for stuffing chairs and couch seats. The best kind is called "medicated cotton" when it is impregnated with drugs; it is also much used to dress scalds and burns, for which it is the best application, and is largely adopted in hospitals.

Cotton Flocks.—These are the waste from "willowing" cotton (see page 7), and great quantities are sold for making cheap beds, and for filling mattresses. Of this we shall speak more fully when we describe the trades in which they are used.

Of late years, very fine doubled-cotton yarn has been used to mix with silk, and for this purpose the yarn has been spun so fine that a pound of it would reach about 200 miles. We may here mention that cotton yarns are named according to the number of hanks, of about 840 yards each, that they require to weigh a pound. Thus, if seven hanks were needed, the yarn would be called No. 7; if fourteen hanks, No. 14, and so on.

The reeling of sewing cottons forms a separate branch of business, but is often largely carried on by the doubler. A very ingenious machine, invented by a workman, was shown to us some time ago by Mr. Coats, of Paisley, who is a large manufacturer of sewing cottons. By a curious arrangement, a piece of rough wood, a little thicker than the intended reel, when put into one end of the machine, is soon turned out a complete reel, and thus the labour of hand-turning is saved. When sewing cottons are reeled by hand, a machine, somewhat resembling that which we described at page 10 as the old kind of spinning wheel, is used; but the reel is fixed on the spindle, whilst the hank is stretched round a reel or "swift," to hold it whilst it is being wound off.

FLAX AND ITS SUBSTITUTES.

The trade and manufacture of flax is one of the oldest which man has followed. It is often mentioned in ancient history, both of sacred and of heathen writers, and it was considered an honourable duty of the women of the household to spin and weave linen clothes: Solomon, indeed, in the Proverbs, mentions the pursuit of that duty as showing the best of qualities in a good wife. At the present time, however, machinery has put hand-spinning almost entirely out of fashion, and, as in every other case, has made the manufactured article much cheaper. The flax manufacture is now chiefly carried on in Yorkshire, many parts of Scotland, especially about Dundee and neighbouring towns, and in the North of Ireland, where the celebrated "Irish linens" and "cambric" are largely produced.

Before describing the flax manufacture, we shall give our young readers an account of the various sources whence we draw our material for the linen and similar trades. Every part of the world produces plants which contain some kind of fibre of the flax or hemp kind; but, like wool and cotton, these substances vary in their staple; that is, some are long and coarse, others are fine, and some are short and brittle. It is the business of the manufacturer to select such as will suit his purpose, and we shall find that he has an abundant choice. Flax, like sheep's-wool, depends much upon the climate; and countries similar to our own, which are termed "temperate," are the best for producing this valuable material. We shall first describe substances used in place of flax, and afterwards deal with the manufacture and trade generally; for the various materials we shall name are all treated in a nearly similar way in preparing, spinning, and weaving them.

China-grass, or Rhea-fibre, is produced from a plant of the nettle kind, and is a native of China, India, and the Indian Islands. It is a fine material, and can be employed in making linens, cambric for pocket handkerchiefs, and similar articles. While speaking of the nettle, we may mention that some beautiful articles have been produced in Ireland from a species of that humble and neglected little plant.

The leaves of the *Banana* and *Plantain,* natives of India, afford a fibre suitable for a vast variety of purposes, and some species of pine-apple afford a similar fibre from their leaves: this is called Pita-fibre.

Bow-string hemp, Jute, Manila-hemp, Yercum-fibre, *Sunn-hemp*, and many others, all natives of India, may also be used for like purposes. But one of the most generally used substances is hemp, a native of most parts of Europe and India. It is largely employed in making sail-cloth, cordage, hempen-cloth for packing, &c., either with or without jute, which has of late years been also used alone for spinning into yarn and weaving into cloth.

It will thus be seen that, as in the cotton and wool trades, our supply of material is largely drawn from foreign countries. Flax, however, the staple article of the linen trade, is grown both in England and Ireland. The plant often forms an ornament in our flower gardens, its small blue flowers being very pretty. Its seeds are the lintseed of commerce, which, on being pressed, afford lintseed oil, so largely used by painters, varnish makers, and others. The cake left after the oil has been extracted, is the "oil cake" used for fattening cattle, and it goes largely to produce the prize oxen which form the great attraction in our Christmas cattle shows. Thus we see how many are the valuable uses to which the productions of nature may be applied by man. A large proportion of the flax used in our country is imported from Russia and other parts of Europe.

When the plant is just becoming ripe, it is pulled up by its roots and dried, the seeds being threshed out in a manner somewhat like that followed with corn. It is then "retted;" that is, the useless matter is separated from the fibre. The "retting" process consists of soaking the stems of the plants in tanks or ponds, where, after putrefaction has taken place, the fibres lose a kind of glutinous or glue-like coat. On this being completed, the plants are removed from the ponds, and laid out in rows on the grass to dry, being freely exposed to the sun and air. When dry, they are passed through rollers to break the woody matter out, and "scutched" by a machine fitted with spikes. The flax is then fit for the use of the manufacturer. The next process is that of "heckling," the fibres having first been cut into three pieces, of which the middle affords the best article. The "heckling machine" consists of a number of clamps or vices, which hold one end of the flax whilst the other is "heckled" or combed by moving teeth or spikes: the fibre is thus cleaned, and rendered of a rich silky appearance. It is then sorted into two classes—the "line," which has the longest and finest staple—and the "tow," consisting of that irregular fibre used to make a low kind of articles.

Flax spinning is in almost every respect like that of cotton, with the exception that it is usually spun whilst wetted with water. This is considered necessary to produce a fine and even thread. The yarn, both in the single and double state, has many uses. Shoemakers employ it to sew the upper leathers and soles together. It forms the sewing thread of tailors and domestic use; and the tow is largely employed in making string, ropes, &c., of which we shall speak more fully under the head of the Sail and Rope-maker's trades.

The weaving of linen goods is carried on in an exactly similar manner to that adopted in producing calicoes, to which our young friends can refer at page 12. Amongst articles thus produced are damasks for table-cloths, linens for shirts, &c.; towelling, table linen, diapers for napkins, &c.; cambric for pocket handkerchiefs, and many articles which we need not name here. The bleaching and dyeing of such goods we shall describe under the head of those trades.

Amongst the lower kinds of linen cloth are, bagging, used for bags and wrappers; sacking, intended for potato, flour, coal, and other sacks; canvas, &c., all of which are sold in the brown state, and undergo no process after that of weaving.

WOOL.

There are none of our young readers who are unacquainted with the source whence wool is obtained, the sheep of our own country largely supplying us with that valuable and warm material, of which our flannels, cloth for coats, and many articles of dress are made. But we cannot depend on our own sheep for a full supply, and hence an immense quantity of wool is imported from many foreign countries throughout the globe. We require a variety in the "staple;" that is, in the length and strength of each single fibre of wools; and these qualities vary according to the heat or cold of the country, the pasturage or grass on which the sheep feed, and, lastly, on the sheep themselves, of which there are numerous varieties.

In our own country, Leicestershire, and many of the adjacent counties, with Kent, Sussex, and others in the South of England, supply us with long-stapled wool. Ireland and Scotland also afford wool, but generally of an inferior quality to the English. On the Continent of Europe, Germany, France, and Spain give large supplies of good fine wool. From the Cape of Good Hope, or rather Cape Colony, Algoa Bay, and Natal, we draw large supplies. In Asia, Turkey and Asia Minor, but especially our colonies in India, send much wool to this country, the Indian kind being like the cotton, coarse and short in staple. Our colonies in Australia, however, are amongst the most valuable of all our sources of wool. The extensive sheep walks in those countries, New Zealand, and Tasmania produce a very fine wool, highly suitable for the purposes of the trade.

Foreign wools, as these are called, are generally brought to London, where they are sold at "wool sales" held at stated periods; whilst British wools are gathered and sold in our large towns by persons called "wool-staplers," whose business it is also to sort out the different kinds, so as to suit the wants of their various customers, who require coarse or fine wools according to the articles they manufacture.

The method of obtaining the wool from the sheep is called sheep-shearing; and this is done on the farms where the sheep are grown, at various seasons of the year, but chiefly in spring, when the animal no longer requires the warm coating which has protected it during the cold weather of winter. The sheep are washed in a pond, and their legs being tied together to keep them quiet, the shearer neatly clips off the "fleece"—that is the wool—in one piece, by means of a pair of large scissors called "shears." The younger the sheep, the finer and shorter the wool; hence the name of "lamb's-wool," applied to that obtained from young animals.

Small farmers and their families often help to get a living by knitting stockings, shirts, &c., by hand, which is common in many of the northern counties of England, and in Scotland, but especially in the Shetland and Orkney Islands; for there such articles afford a chief means by which the poor inhabitants obtain money. Their land produces scarcely anything valuable but the grass on which their sheep are fed.

All wool is more or less covered with a greasy matter called the "yolk," and it is the business of the wool-scourer to remove this. It may be done either before or after the manufacture of the yarn or thread produced by spinning. The process is very simple, consisting merely of washing the wool or yarn with soap and hot water, by which the greasy matter is quite removed. The wool then becomes beautifully white, if it had not previously a colour of its own. This, however, is frequently the case, as many sheep are of a brown or blackish colour, and this is of course retained even after the scouring has been completed.

Wool is bleached in a very different way from cotton. After it is scoured, it is exposed to the fumes of burning brimstone, by which it acquires a beautiful creamy-white colour. Our young friends may easily try this by first washing some wool, as obtained from the sheep's back, in hot water with yellow soap. This will illustrate the *scouring* process. A little brimstone is to be placed on a shovel heated nearly red hot; the wool, which must be slightly wetted—in fact, just as it has been wrung with the hand out of the soap-suds, and then washed in warm water and squeezed—is then to be held so that the fumes of the burning brimstone may rise into it, and it will soon become quite white. Straw bonnets are bleached in a similar way, and a red rose may be turned quite white by the same means.

Short and long stapled wools are treated in an entirely different manner before spinning. The short kinds are mixed together, then "scribbled," or opened out, and afterwards carded like cotton, oil being added to keep the fibres together, and so prevent the waste which would otherwise occur. The remaining processes are more or less like cotton spinning by the mule frame (see page 8), and therefore do not need further description. Some wools are of a very long staple; that is, each fibre may be two, three, or even more inches long, and such wools are combed. These are used for worsted, hosiery, &c.

The combs are made of thick steel wires, each several inches in length, and fitted with a handle. They are first made hot, and the wool is passed through them so as to lay its fibres all parallel, or side by side, just as is done by the carding engine with the shorter sort. The operation is very simple, and is easily imitated by passing a lock of wool through two common hair-combs, which give an imperfect illustration of the process, but sufficiently explain it. The wool thus combed is then fit for the process of spinning, doubling, &c.

We have thus given an account of the operations required before wool is woven. The yarn is converted into a variety of useful purposes, as, for example, the worsted used for fringes and mending stockings, "Berlin wool" for ornamental work, &c., the method of doubling being similar to that employed for cotton, only that the wool is doubled much more loosely. Its manufacture into stockings, and similarly made articles, we shall speak of under the head of the trade of the hosier; and, in respect to weaving, we shall select cloth used for making coats, as giving the most interesting operations. Amongst the lowest uses to which coarse woollen yarn is put, that of the making of mops for house and ship use is the most common. The yarn for this purpose is chiefly spun at Witney, in Oxfordshire. It is very coarse, and three threads are generally "doubled" together. The thread thus formed is wound round a piece of wood, and the ends are then cut through with a sharp knife. The middle of the bundle is tied tightly with tarred cord, and in the centre a nail is driven by which the mop can be attached to a stick. Trifling an article as a mop may appear, many thousand pounds' worth are sold annually, a large proportion being used on board ships, especially in the Naval service and the Dockyards. We may here mention that blankets, which are woven by the hand-loom, are chiefly made at Witney, and form an important article of manufacture in that town.

THE CLOTH MANUFACTURER.

Before describing the process of making the woollen cloth of which men's coats, &c., are made, we must call the attention of our young friends to a curious property which certain kinds of wool possess; it is that of "felting." By this we mean that when a number of fibres of the wool are beaten together with a little moisture, they have the power of uniting, and so forming a solid mass, an illustration of which is found in the common felt carpets of our houses. This felting or fulling process we shall presently describe.

The quality of a piece of cloth, of course, depends on that of the wool from which it is made; and we can here give a piece of information at which many of our readers will be much surprised. It is, that the cloth of which the coarser kind and lower-priced garments for men are made, is to a large extent produced from old carpets, stockings, and other refuse of our houses!! Marine store dealers purchase this refuse, and it is sent to Leeds, and other towns in Yorkshire, to be broken up by means of a machine called a "devil." This consists of a large cylinder covered with steel teeth, over which rollers, similarly covered, revolve. The waste articles are gradually introduced into the machine, and are so completely torn to pieces that they become a second time fit for spinning. In this state the material is called "shoddy," and it requires to be mixed with some longer stapled wool, to carry it through the spinning process. It undergoes more or less those operations which we are about to describe, after the yarn has been woven into cloth, which is done in a similar manner to that of weaving cotton by the hand-loom.

We shall not here describe the process of dyeing the cloth, as that will be explained under the head of "the Dyer," but we must point out the distinction which exists between "wool-dyed" and "piece-dyed" goods. In the former, the wool is dyed before spinning, whilst the "piece-dyed" consists of articles dyed after the cloth is woven. The wool-dyed article always wears best, because the dyeing material more fully penetrates the wool in the raw state than when it has been manufactured.

The cloth requires scouring, a process which we have already described. It is then conveyed to the "fulling stocks," which consist of troughs, in which the cloth is placed, with soap and water. Heavy blocks or hammers are fixed over the trough, and by means of steam power they are lifted up and down, so as to beat the cloth heavily, the hammer or block being called a "stock." The supply of soap is continually renewed, and the cloth is frequently shifted, so that every part may be fully exposed to the beating action of the stocks. By this means all the fibres of the web are laid across each other, owing to the minute hairs, which extend in all directions from each fibre of wool, becoming bound together. The cloth after thus having been beaten becomes almost a solid mass, and the operation of "fulling" or "felting" is completed. It is then dried in a room heated by steam, and so becomes ready for an important and curious operation.

All our young readers are acquainted with what is called the "nap" of cloth, and to raise this from the material brought from the fulling mill, the "teazle" is employed. The plant which produces this is common in many of our hedges, but is largely cultivated in some parts of the West of England expressly for the use of the clothier. The head or fruit of the plant somewhat resembles that of a thistle, but it is larger, and possesses long hair-like points, which make it of value to the cloth manufacturer. The edges of these points end in a kind of hook. Rollers, covered with fine wires, are sometimes used in place of the teazle; but the ends of the latter being more elastic, serve the purpose more completely. The cloth is hung on a kind of frame, and the teazles or iron wires being fixed in a suitable frame, are rubbed against the woollen fibres until a portion is drawn out from the felted surface, so as to form the future "nap" of the cloth.

The next process is that of "shearing," which is effected either by a pair of scissors in the hands of the workman, or by knives driven by machinery. The whole surface of the cloth is thus converted into a soft downy substance, somewhat resembling the coat of velvets, which are in fact produced by similar means. The end of each fibre stands out from the web of cloth, and gives it a soft touch to the hand. The best kind of cloth is sheared two or three times, so that it may be perfectly smooth and even over its whole surface. After the nap is thus raised, the web goes through various operations as picking, boiling, steaming, pressing, &c., and it is at last brushed, so as to set the fibres in one direction. It then becomes ready for the handiwork of the tailor and others.

As we have already remarked, Yorkshire is a seat of the woollen manufacture, Halifax, Dewsbury, Bradford, Huddersfield, and numerous smaller and adjacent towns, some of which have been created by the trade, being the centre. In the larger towns weekly markets are held, at which the cloth is sold to wholesale dealers, who distribute them throughout the country. In the West of England the cloth manufacture is also carried on, and the goods there produced have long been held as superior to any other, although no reason exists to give the manufactures any special advantage.

Such is an outline of the processes through which wool passes before it becomes the cloth of our garments. But there are numerous kinds of woollen cloth besides those we have named, which our space forbids us to fully describe in respect to the process of their manufacture. For example, there are merinos, moreens, damasks, baize, flannel, stuffs; mixtures of cotton, silk, and wool; forming a long list of material for ladies' dresses, shawls, crape, &c. The principle of the manufacture is much the same as that we have explained, altered, however, to suit the peculiarity of each article.

Some of the Indian wool manufactures are highly prized, amongst which may be named the true Cashmere shawls, which are made from the hair of a species of goat called the Cashmere goat. These shawls are imitated in our country, and are manufactured from fine wool, but they are greatly inferior to the true article.

The hair or wool of many animals besides the sheep is used in a similar manner, as, for instance, the hair of the alpaca, an animal indigenous to South America, and many of the goat kind.

The waste of some kinds of the wool manufacture forms woollen flocks used in mattresses, and wool carded like cotton is used in stuffing chairs, and to form the body of muffs, boas, and other articles made by the furrier, of which we shall speak when describing his trade. The carpet manufacture will be explained under a separate head, in connection with house furniture, and trades connected with it.

THE SILK TRADE.

There are perhaps few, if any, of our readers who have not seen the silk-worm, and noticed its changes into the grub or chrysalis state, before entering into which, it spins a cocoon. It will be therefore unnecessary to describe the worm; but we shall detail the different stages through which it passes, until it affords us the favourite material of our richest garments.

There is little doubt that the silk trade had its origin in China, where the rearing of the worm is still so largely carried on. It does not seem, however, to have been known in Europe till about the year 560 of our era. About the fifteenth century attempts were made to rear the worm in England, which, like all experiments of the same kind since, proved quite useless.

The eggs of the worm are of about the size of a pin's head, and the creature, when hatched, is not longer than the tenth part of an inch (that is, less than half a quarter of an inch): it then resembles a thin black thread. If well fed, it soon grows, and sheds its skin four times before it commences spinning, which occurs in about a month from its birth. One ounce of the eggs will produce worms sufficient to eat half a ton of mulberry leaves, between their birth and change into the chrysalis state; and the worms which produce a pound of cocoons eat about fourteen pounds of leaves during the same period. One hundred eggs weigh but one grain, but the worms produced from them will weigh nearly ten thousand times as much, or about a pound and a half avoirdupois, by the time they spin. It takes about three thousand worms to spin silk enough to make a lady's dress.

Having given these particulars as most likely to interest our young friends, we shall now describe the method of obtaining and manufacturing the silk.

At about four or five weeks from its being hatched, the worm becomes sickly, and ceases to feed. It then begins to spin, from two small holes in its head, a fine thread; and gradually encloses itself in a small oval ball called the "cocoon." Having finished this, it changes into a grub or chrysalis, which, if left to itself, would soon be turned into a moth; this, eating its way through the cocoon, would destroy it, and, to prevent that, all the grubs or chrysalides are killed by heating the cocoons containing them, except so many as may be required to supply eggs for the ensuing season.

The cocoons intended to afford the silk are thrown into a vessel of hot water, that a kind of gummy matter which adheres to the thread may be dissolved away, otherwise, the silk could not be wound off. The ends of a number of cocoons are then joined together, and the silk is wound off on to a kind of reel. Girls are employed for this purpose in China; and in a similar way the silk is obtained in Bengal, Persia, Italy, France and Spain, in all of which countries the worm is also reared, and large quantities of silk produced. The colour of the silk varies from a rich golden yellow to a white colour, and each separate thread or filament is so fine as to readily float in the air. The length that can be used of each thread is about three hundred yards, but the actual length is much greater.

The silk is then collected and made up into hanks, and in this condition it becomes ready for "silk throwing," a process somewhat like that of the spinning of cotton, but differing in many important points, because that substance consists of fibres but an inch or so long, whilst, as we have just mentioned, the fibre of silk extends several hundred yards in one unbroken length.

The first step is to wind the silk on to bobbins, which is done by a machine of simple construction. The bobbins being filled, are then placed in a twisting machine, somewhat like that used to make sewing cottons, and thus a sufficient number of threads are united together to give the new thread the strength requisite for its subsequent uses. Two or more of these threads, twisted together, form the "silk twist" used by tailors and others for sewing purposes. It is in fact the same twist that is bought on reels at the shops, but varies in strength and thickness according to the purpose for which it is required.

The waste silk, called floss, which is derived from the cocoon, and in the manufacture of silk thread, is also used up; but being short and in broken pieces, it is carded and spun after the same fashion as cotton, being often mixed with a little jute (see pp. 7, 8), to give it strength and to lessen its price. This is often woven to make very common "silks," especially cheap "silk" handkerchiefs, commonly sold in our drapers' shops.

But for broad silks, velvets, ribbons, &c., the silk is used as it is obtained from the twisting machine, before doubling it for sewing thread. It is then woven in a loom, similarly to cotton, the process being carried on by weavers, who are supplied by the manufacturer with the silk, on the bobbins, already dyed of the requisite colour. The mode of dyeing silk we shall speak of under the head of the Dyer's trade.

Silk weaving has long been largely carried on at Spitalfields, at the east of London; but it has gradually spread throughout our large manufacturing towns, such as Manchester, Glasgow, &c. Ribbons are chiefly produced at Coventry in this country, whilst Leek, Macclesfield, and Derby are noted for the sewing-twist manufacture. Silk stockings are produced in Nottingham and Leicester; Glasgow is noted for its bandana handkerchiefs, and Dublin for Irish poplins, a kind of broad silk much admired for ladies' dresses. In France, Lyons has long been noted for its silk manufactures, which are also carried on in many of the leading towns of that country. From Persia, India, China, and Japan, most beautifully worked silks, used for all sorts of purposes, are sent to this country.

For working raised patterns in silks, a Jacquard loom is employed. It much resembles that we have already described when speaking of cotton weaving, but has a peculiar arrangement by which the pattern is worked, which we shall describe when explaining the carpet manufacture. Velvets differ from ordinary silks in having the top surface cut with a sharp knife, so that the ends of each thread may rise above the ordinary level of the piece. The gloss of the broad silk is lost, but a peculiar and fine rich appearance is produced. In making both broad silks and velvets, fine cotton thread is sometimes used; and, indeed, some of the cotton thus employed costs nearly as much as the silk with which it is mixed. It gives what is called "body;" that is, it renders the piece stouter and thicker; often, however, the cotton is added to lessen the cost, and then, being of a coarse kind, it much lowers the value of the goods. Silks for umbrellas, parasols, and the like, are thus manufactured. Silk plush, used for making hats and ladies' bonnets, will be described when we speak of the trade of the Hatter.

THE BLEACHER.

Having described the various processes by which cotton, flax, wool, silk, &c., are manufactured, so as to fit them for general use, as clothing, &c., we shall now proceed to describe to our young readers the methods which are followed for either rendering such articles of a pure white colour, or of ornamenting them, either wholly or in part, with colours. These trades are divisible into three—namely, those of the bleacher, dyer, and calico-printer, with the first of which we shall commence.

The object of bleaching is to remove the natural dark-brown or yellow colour which cotton, flaxen, woollen, and silken goods possess. The two last are always bleached by washing and the action of fumes arising from burning sulphur, the uses of which have been explained in connection with wool, at page 24. We shall therefore here only have to refer specially to the bleaching of vegetable substances, as cotton and linen goods.

In former times, bleaching of this kind was carried on solely by the action of air and light, in what are called "bleachfields;" and, indeed, some kinds of linen are still bleached by the same method, hence the name "grass-bleached," occasionally marked on some kinds of Irish linens. The goods are boiled in a solution of either pearl-ash or soda with lime, to remove grease and rosin-like matter which they contain. They are then well washed in water, and laid out on the grass of a large field in an open country. By repeated boiling, washing, and exposure to the air on the grass, the yarn or cloth is thus bleached.

But the method is exceedingly slow; even in fine weather it would take about six weeks to effect a complete bleaching, and in unfavourable times sometimes months might elapse before the trader would get his goods back. The science of chemistry at last solved the difficulty, and by means of "chlorine," the nature of which we will presently explain, the bleacher can now do in as many hours, and in a far better manner, work which formerly it took weeks to perform.

Chlorine derives its name from a Greek word signifying a greenish colour, that being the colour of this gas. It is obtained from common salt; for, strange to say, that harmless, nay, necessary substance, consists only of a metal and this gas. They are both deadly poisons if taken separately into our bodies, but when united together, form the salt whence the sea possesses its saltish taste; the salt used at our tables; and which is found not only in our own bodies, but in those of all animals which supply us with food, and in most of the corn and vegetables which we eat. Chemistry discloses to us many such surprising things, and reveals in an astonishing manner the goodness and wisdom of the Creator.

"Bleaching powder" is the substance that the bleacher uses, and it is the same as the "chloride of lime," which we employ in our houses to destroy the smell of drains, &c. This powder is made by putting common salt, black manganese, and oil of vitriol or sulphuric acid (obtained by burning brimstone) into an iron vessel lined with lead. From this vessel the fumes, or gas, which is chlorine, are conducted to a chamber containing lime, used also in making mortar. The lime is put into shallow trays, and as the chlorine gas obtained from the salt in the other vessel passes over it, "chloride of lime," or "bleaching powder," is produced. This is removed and packed in casks, in which form the bleacher receives it. In Glasgow, Messrs. Tennant largely manufacture this substance; indeed, it was discovered some years ago by a late member of this firm. At their works is a very tall chimney, about 430 feet high, that has been built to carry off the noxious fumes of this and manufactures of soap, &c., which they also carry on. It also serves as the receptacle of smoke from their numerous furnaces. Other works of the kind are found at Manchester, Warrington, Newcastle, and other places, at all of which the sulphuric acid, of which we have just spoken, together with soda—both used by bleachers—are produced besides the bleaching powder. The bleacher can therefore supply all his wants from any single factory of the kind.

We must now visit the bleach-house. It generally consists of a number of low sheds, sometimes open at the sides, but always at the top, so that the steam, fumes, &c., may readily pass off. It forms a singular contrast to the order which we have noticed as always kept in the cotton factory. We observe large boilers supplying the steam, by which the contents of the tubs and vats are kept boiling, for fires are never used for this purpose. The steam from the boilers is conveyed by means of iron pipes to the vats; that part of the pipe which enters the liquor being generally made of lead, because that metal is less acted on by the chemicals than most others. By means of a stopcock the steam can be let on or off as needed, and when it does blow into the water to boil, it makes a noise which soon deafens the stranger. The men, however, get used to it, and can easily hear each other even when speaking in a low voice. On the floors of the bleach-houses rails are laid, like those used on railways, and by means of trucks with railway-like wheels, heavy weights of goods can be moved about by mere lads, from one part of the works to another. There is one quiet place in the works, and that is the chemist's laboratory or workshop, where he tries or tests all the substances used in bleaching, and sees how far he can find out new methods of doing the work, carried out in the bleach-house, in a better and cheaper manner.

Yarn and cloth are bleached after precisely the same principles, but the difference of their form, size, &c., requires that certain parts of the processes should be suited to their special character. We shall first describe the method of treating the yarn or sewing cottons, and then speak of that followed in bleaching calicoes, and other woven articles.

The yarn or sewing cottons are sent to the bleachers in bundles of about ten pounds' weight; and each end of the hanks is tied with a piece of cord, by which they are kept separate, and can be removed from the vats after each process. The first step is to cleanse them thoroughly of all grease, and the resinous matter they contain; and this is done by boiling them in vats containing lime or soda, sometimes both. They are then carefully washed by placing them in a large drum or wheel, through which water is kept passing. The drum is made to revolve rapidly, and thus all parts of the yarn are exposed to the action of the water. The same machine is also used to wash the calicoes, and by a simple arrangement it can be made to dry them, for whilst turning round rapidly when thus used, the water is driven out with great force. Acting in this way, the machine is worked on the plan which we adopt in trundling a wet mop, by making it turn rapidly round. If our young friends try this experiment, they will find that the water flies off in every direction, owing to what philosophers call "centrifugal force," or force flying from a centre. In this way, and for the same reason, the drying machine acts.

Taken from the washing machine, the yarn is dipped into the "sour," which consists of water with just as much sulphuric acid added to it as will make it taste like lemon juice. This "sour" dissolves away the rust or oxide of iron, which, if left either in the yarn or cloth, would give it a brown or yellow colour, resembling (and from the same cause) the "iron-moulds" produced by ink when it falls on white calico, &c.

After "souring" and washing, the yarn is thrown into a strong solution of bleaching powder, and here it first assumes a white appearance. It is removed from this liquor, and left to drain for a short time, being afterwards thrown into a fresh souring vat, where it gradually becomes quite white. If necessary, these processes are repeated until the yarn is as white as snow. The remaining processes are those of washing and drying, by means of the wheels already described, when the hanks are separated from each other, hung up in the drying-house, after which they are packed in bundles, then pressed and wrapped in paper. Generally speaking, however, before being dried, they are dipped into a vat containing a little "blue," so as to correct a slight yellow colour they might acquire by keeping. This operation is the same as that which our laundry women use in finishing muslins and linen articles after washing, only that it is done to a greater extent by the bleacher. Hence the beautiful bluish-green colour which sewing cottons have in the hank, when held up to the light.

Calico-bleaching is carried on in exactly the same manner as we have here described, so far as the chemical part of the business is concerned, but the cloth is not thrown into the vats, as is done with yarn. When the brown cloth is to be bleached, a large number of pieces are sewn end to end, so as to form one long continuous web even miles in length; and the beginning of this is slipped under and over rollers placed in and above the vats. The cloth is kept slowly, but constantly, moving in and out of the vats by means of steam power; and it thus passes through all the processes we have described, until at last it leaves the washing tub perfectly bleached. If it has to be sold as white calico, it is then dressed with a paste of flour or potato starch, and passed over hot metal rollers to dry it; afterwards it is also passed over and under polished paper rollers to give it a bright glazed surface. Each piece is then separated, and, being measured, folded, pressed, and labelled, it is ready for sale to the wholesale draper, from whom it passes to the retail trader. It is afterwards converted, by the nimble fingers of the workwoman or the sewing machine, into shirts and other articles of dress, with which every one of our young readers is well acquainted.

But a large proportion of the calico made in this country is "printed;" hence the cotton articles worn as morning and other dresses by ladies and domestics. It will be our business, therefore, to describe another trade—that of the calico-printer, who receives the calico before it is "dressed" or finished after the method we have just explained. But before doing this, we must examine the processes which the dyer uses, because we must thoroughly understand his art, before we can hope to comprehend that of calico-printing. The dyer, in fact, almost always precedes the calico-printer in producing printed cottons, so far as the order of each operation is concerned.

THE DYER.

Amongst the various arts that man has practised, that of dyeing is one of the most ancient. It is often spoken of in the Scriptures, and the old heathen writers also frequently refer to and describe it. The beauty of the "Tyrian purple," which it is believed was invented about one thousand years before our era, was celebrated throughout the then civilized world.

Even in our day, we find that savage tribes of most newly discovered places have discovered some way of colouring their articles of dress, and of painting their bodies and faces. Our ancestors, in this country, when in a barbarous state, were in the habit of painting their bodies with the juice of woad. This affords a blue colour, and is a native of our land; indeed, it is now frequently used, and was formerly much more so, until indigo was introduced, which has, to a large extent, taken its place.

We can fortunately suggest some simple experiments to our young friends, by which they may easily learn the principles on which the dyer's art depends; and, indeed, we can teach them how to dye any small article they may desire. Of course, these attempts will not be so successful in result as those made by the practised workman; but, still, they will serve both to interest and instruct our readers,—an object which it has been our constant endeavour to keep in view throughout this little book.

The art of dyeing consists in fixing on any cotton, linen, silk, or woollen article, a colour different to that which it already possesses; and which colour, when so imparted, shall remain for a shorter or longer time fixed or permanent. Hence dyeing differs from staining, as in our accidentally dropping the juice of fruits, &c., on a dress, for such stains readily wash out, whilst the dye, if good, remains unchanged when washed.

Generally speaking, the liquor obtained by boiling a root, the leaves, or flowers, &c., of certain plants in water, is the source of the colouring matter of the dyer. But if he only dipped, or even boiled, the cloth in such a liquor, he would not *dye* it, he would simply *stain* it; and hence, if a dress were thus treated, the first time that it was washed, the colour would be all "washed out." Hence his labour would be in vain.—We must therefore explain how it is that the colours can be fixed on cloth, &c.

For that purpose *mordants* are used. They derive their name from the Latin word *mordere*, to bite; because it was at first supposed that they "bit" the colour into the article. This, however, is a fanciful idea, for their real object and action is that of making the colouring matter insoluble, or, in other words, of so fixing it that it shall not be removable by water either hot or cold, or by the soap and soda generally used in our houses for cleansing the articles of dress we wear.

An instance of the necessity of a "mordant" may be found as follows :—Dip a piece of calico into hot water to soak it, and then squeeze it well with the hand, to remove as much liquid as possible. Afterwards, dip it into a tea-cup containing a little ink, and hang it up to dry. If it be washed in hot soap and water, the colour will be changed to a brown, because it is not fixed. This, then, is an instance of simple staining, for the ink will not *dye* the cotton of the same colour as the ink, because the black of the ink is already insoluble, and cannot enter the tubes of the cotton.

If, however, instead of using the ink, we employ the materials of or from which the ink is made, we may dye the calico of a permanent black, and for this purpose we must use a "mordant," which will be iron. Our young friends may take their first lesson on dyeing as follows :—

Boil a handful of logwood chips in half a pint of water for about an hour; and whilst still hot, strain off all the wood by passing the liquor through a piece of coarse net, or muslin, into a basin. In *another* basin dissolve an ounce of green copperas, in half a pint of warm water. Dip a piece of white calico in the logwood liquor, leaving it there until the cloth is thoroughly coloured. Then remove it, squeeze it in the hand, and dip it into the basin containing the copperas solution. The cloth will gradually acquire a bluish slate colour. It is then to be taken out, squeezed, and hung for two hours in the open air. The logwood solution is to be made warm, and the cloth must be again dipped into it, afterwards to be squeezed, and then to be dipped again into the copperas solution. If the entire process be repeated three or four times, the cloth will at last be dyed black, and it may then be washed in cold water and dried.

A piece of cloth dyed this way will stand washing in soap and water, because the iron which the copperas contains has seized the dye-matter of the logwood (called tannic and gallic acids), and rendered it insoluble in water. In fact, by this simple experiment we have put *solid* ink into the fibre of the cloth, instead of liquid ink, as by our first experiment; and hence we have *dyed* instead of *stained* the cloth.

If, instead of logwood, a solution of a quarter of an ounce of yellow prussiate of potash, in half a pint of cold water, had been used, and the experiment had been carried out in all other respects in the same manner as that just described, the calico would be dyed of a blue colour, because the iron of the copperas, acting still as a mordant, would have formed another substance which, in this case, produces the colour called Prussian blue.

Another and pretty experiment of the same kind may be tried instead of the last one :—Soak a piece of clean white writing paper in the solution of the prussiate of potash just named. Dry the paper, and then write on it, by means of a quill pen, with a solution of copperas. The marks will all appear of a beautiful blue colour, for the same reason that the calico obtained that colour when dyed as in the last experiment.

If our young friends will try these simple experiments, they will learn *all* the principles on which the dyer depends in his art. Of course, he does not always use the same mordant, for he chooses such as will best agree with the colouring liquor he is using. For instance, a solution of tin, called "spirits," gives a splendid red colour with Sappan, Brazil, and other red woods; and in this case tin, instead of iron, becomes the mordant. These latter are very numerous; but as we do not wish to make our young readers practical dyers, and only teach them the principles of the art, it will be unnecessary for us to give a full list of the various mordants in general use.

Before speaking of the colours which various substances afford, we may say a word or two about the nature of colours. It would be naturally supposed that when we see any coloured body, its colour could always be seen in whatever light we may hold it; but such is not the case, as may be readily found by trying the following experiment. Put some salt into a saucer, and pour on it two or three table-spoonfuls of strong whisky, or, what is better, spirits of wine. Take this into a dark room, and having set the spirit on fire, hold near the flame a few ribbons of a light yellow, red, and blue colour, stirring the salt and spirit together at the same time. Instead of the ribbons presenting their "natural" colours, they will all seem of the same colour, and so will the faces of those who may be looking on.—Why is this? It is simply owing to the fact that the light falling on them is *one-coloured*, or, as it is called in science, *mono-chromatic*, which means the same thing. But white light, as of the sun, is *not one-coloured.* It contains many colours, and a coloured body reflects to our eye *one* of these colours out of those forming white light.

In a similar way, if a prism, or the three-sided pendant of a chandelier, be held in the light of the sun, so that the colours into which it divides light may fall on to a sheet of white paper, *any coloured body*, held in *any one* of the colours seen on the paper, will take the colour in which it is held, no matter what its own may be. Thus the burning salt and the prism show us the nature of colour, and the reason why bodies present the various tints we observe. Depending on the principles we have named, is the fact that ladies never choose coloured dresses by candle light, because it contains so much more yellow than white light, as to turn blues to greens, and generally to give an entirely different appearance to that which the same article would show by day-light. In dyeing, this last fact is often taken advantage of, for green colours are produced by first dyeing the cloth yellow, and afterwards blue; orange, by first dyeing yellow and then red; purple, by red and blue dyes. If our young friends watch the colours produced by the prism, or in the rainbow, when the rain acts as a prism, these colours are similarly afforded by the overlaying or mixing of either red, yellow, or blue. These three colours are therefore called primary, because from their mixture all others are producible.

We must now return to the dyer. The chief implements of his trade are large tubs or vats to hold the liquors; rods, posts, or presses to wring the goods after being passed through the vats; coppers to heat the liquors, or—what is still better, and almost universally used at the present day—a boiler from which the steam is led, by means of pipes, into the vats, so that the liquors may be heated.

The plants which afford the colours are very numerous; and, as we have already said the root, stem, bark, leaves, and flowers are all used for dyeing materials, we shall give an account of some of the most important under the heads of the colours they produce. It must be remembered, however, that with different mordants the same material will give other colours. Thus logwood liquor gives a black with an iron mordant; a red with a tin mordant, and so on.

Black Colours.—These are all produced by an iron mordant and the liquor of any of the following substances:—1. Oak-bark, which is obtained by peeling the bark of the common oak. This, as we shall afterwards see, is much used for tanning purposes. 2. Logwood, which is grown in Central America. 3. Catechu, kino, gambir, &c., the products of the East Indies. 4. Sumac, the leaves of a tree grown in South Europe. 5. Alder-bark, a tree common in this country. 6. Oak-galls, imported from Asia Minor. These are caused by a disease of the oak, arising through the action of a small insect. They consist of little round balls having a bitter taste, and may often be found in our own woods on oak-trees.

Blue Dyes.—Indigo is almost universally used by the dyer. It is obtained from a plant growing in India, and is brought into this country in the shape of cakes about two inches square. Our young friends will have seen this substance in use by the laundry woman for "blueing" the articles that have been washed. It is a troublesome dye, but gives a fine blue, that stands washing, and hence it is highly prized. Woad is also used, as we have previously named.

Green Dyes.—These, as we have already mentioned, are produced by the union of blue and yellow dyes. Indigo being used for the former, and weld, fustic, &c., for the latter colour.

Red Dyes. — These are obtained from alder; arnotto, which is also used to colour cheese in our dairies; cam, or barwood; logwood; Brazil, peach, Lima, and Sappan woods, which all resemble logwood, and are grown in hot climates; lac, the product of an insect's action on a tree; cochineal, a small insect of about the size of a little pea, which feeds on a species of the cactus plant, and is imported from Mexico,—it also affords the carmine used for rouge; kermes, a similar insect; safflower, the flower of a plant, which affords a fine rose-colour; and, lastly, madder, which is the ground root of a plant largely grown in France, &c. The substance affords *garancine*, that is so much used by dyers in producing the celebrated Turkey-red dye.

Yellow Colours.—Alder; arnotto; broom, a plant growing on our heaths, and affording yellow flowers; buckthorn, French, Persian, and other berries; fustic; sumac; heather; quercitron, the bark of a tree of the oak kind; saffron, a kind of crocus which used to be largely grown in Essex,—hence the name of Saffron-Walden, a town in that county; turmeric, a powdered root belonging to a plant of the ginger kind, and also used in curried dishes; weld, and several others.

Some lichens, commonly called mosses, as cudbear, litmus, and other such substances, which grow like moss on stones and trees, are also used in dyeing. They afford violet colours, but have so little fixity as rarely to be used where the dyed material is likely to be exposed to the sun and air.

Coal-tar Colours.—But the most surprising fact in dyeing is, that nearly every colour can be obtained from a source which our readers could scarcely imagine; we mean common *coal-tar*—that stinking liquor which is produced during the making of gas, and is used to cover wooden palings, ships' sides, &c., to protect them from the action of air and water. It would take up too much of our space, and most likely confuse our young readers, were we to attempt to describe the various processes by which "aniline" is obtained from coal-tar; but it is the source of between twenty or thirty colours, varying from the deepest purple and red to the finest blue, and including Magenta, mauve, Solferino, &c. Most of the brilliant coloured blue, red, and various other shades in silk and wool are thus dyed, especially for ribbons and ladies' dresses. We have in this, one of those astonishing and beautiful results which the study of chemistry has afforded. We may add that the pure dyes here named are almost as valuable as their weight in gold, but they are so intense that a little goes a great way.

The *mechanical* operations of dyeing are exactly the same as those of the bleacher; that is, he dips, wrings, dries, &c., in a similar manner, and the same implements of trade are common to both. There is very little difference in the processes of dyeing any material; and such would not interest our young friends, if we were to describe them, for they are purely matters belonging to the practical man.

We may, however, mention the way in which bandana handkerchiefs are dyed and printed. After having been coloured red by the Turkey-red dyeing process, they are placed in a press, by which they are forcibly pressed together. In the plates which cover them, holes are made, corresponding to the pattern which it is desired to form on them. A solution of chloride of lime, which we have already spoken of at page 41, is then allowed to pass into these openings, and wherever it touches the cloth it entirely removes the colour. The liquid is prevented from spreading beyond the desired pattern owing to the great pressure. It is by this means that silk handkerchiefs of other patterns are also dyed or printed; and the Berlin or other wools, which in the hank are only partly dyed, are done in a similar manner, by tying the hank tightly at such portions as it is wished should not be coloured, and dipping the other parts successively in the dye liquor.

THE CALICO-PRINTER.

Our description of the art of dyeing will render it unnecessary for us to enter largely into that of calico-printing, for this trade is really that of dyeing, applied partially to the surface of calico. We shall follow the same plan as that which we adopted in the previous article—namely, that of suggesting experiments, by the trial of which, our young readers may at once learn the art and mystery of the subject, in a manner far more completely than we could hope to teach them by writing.

For this purpose we shall select two modes of calico-printing for illustration: one being that by means of which the colour is *added* to the surface of the calico, and the other that in which it is *removed*. For this purpose the following experiments may be tried:—

1. Dissolve a little copperas in water, and with this wet the end of a clean wooden ruler, such as is used in counting-houses. Press this wetted end on a piece of clean white calico, and repeat the same all over the piece, at intervals of about two inches apart, taking care that the cloth is wetted through where the ruler touches it, and dry the cloth. Next dissolve a few crystals of yellow prussiate of potash in a wine-glassful of water, and then dip the cloth into the solution. Wherever the calico had been previously marked by the ruler, a fine blue colour is produced, for reasons already explained at page 46. This affords a method of printing by *adding the colour to the surface of the cloth.*

2. Take a piece of black calico, or the piece dyed as directed at page 46, and lay it on a few folds of soft paper to form a kind of cushion. Dissolve some tartaric acid, say a tea-spoonful, in half a wine-glass-

ful of water. Into this dip the end of a clean wooden ruler, and press the wetted end on the black cloth. Repeat this two or three times, taking care that the ruler is always replaced *exactly* on the spot it had been previously pressed. In a short time the black will be entirely removed, and a white spot will be produced. The cloth may then be washed in water, and the white will become clear. This is an illustration of the method of printing *by removing a colour*, and is precisely the plan by which black cotton cloth, with white spots, is produced by the calico-printer.

Formerly, calico-printing was carried on by hand. Wooden blocks were used, on which the pattern to be printed was cut; and on this the "mordant" was placed, the use of which we fully explained in our description of dyeing at page 45. The printer then transferred the cloth to the dye-tub, and so the printed pattern was produced on the cloth, as many colours being afforded as there were mordants; for each of these would produce a different colour when dipped in the same dye-stuff. If more colours than could be thus produced were required, then the process was repeated with the block and dye-vat as often as necessary.

Of course, this was a tedious process, and at last machinery was invented by which a piece, or one hundred pieces, of calico could be printed continuously, with scarcely any attention on the part of the printer, except that of keeping the troughs full of colours. It is by this plan that all the cotton dresses worn at the present day are printed; and we shall endeavour to explain the process as simply as we can.

Instead of wooden blocks, copper rollers, about two inches thick, and as long as the piece is wide, are used. On these rollers the pattern is engraved, or cut in. The rollers are then placed in the lower part of the machine, and in front of them are troughs containing the colouring matter prepared from suitable dye-stuffs, that we have already mentioned at page 50. To prevent too much colour passing off, a steel knife, called a "doctor," presses against the roller, and removes all but that sunk into the engraved portion of its surface. The calico, already bleached (but not "finished") in the manner explained at page 43, passes over a cylinder, and is pressed against the copper roller, the colour of which is thus transferred to the cloth. The calico is gradually drawn up overhead; and so fresh surfaces are constantly and continuously being printed: indeed, so long as cloth and colour are supplied, the printing goes on without the least interruption. Each machine is generally driven by a separate steam engine, so that its action may not be disturbed by others that occasionally get out of order.

After the calico is thus printed, it is steamed, so as to improve the colour, run over hot rollers to dry it, and then "calendered," to give it a glossy appearance; the calendering rollers being made of polished

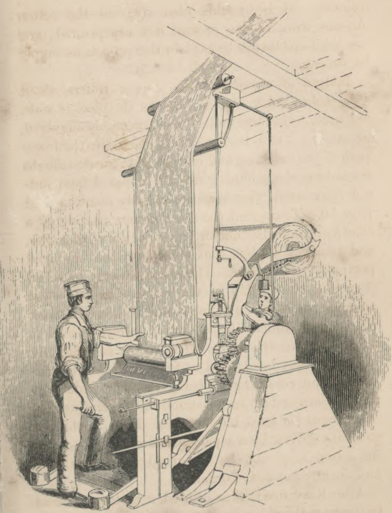


PLATE 5.—CALICO PRINTING MACHINE, p. 56.

wood or paper. The pieces are then separated, measured, folded, and marked, and soon find their way into the market as printed cottons, after which, by aid of the dressmaker, they become converted into "print dresses."

Such is a general outline of the method of printing cotton dresses. We have avoided many details both of the methods we have explained, and others not named, because, had we fully described these, our young readers would have been wearied with details of little interest to them, although of importance to the calico-printer.

THE TANNER.

Amongst the important trades by which the handicraftsman is supplied with material from which our articles of clothing are manufactured, the tanner holds a high place, for on him we depend for the leather of which our boots and shoes are made, besides numerous other objects which are manufactured from that material. His operations convert the skin of animals into a solid substance, which is almost impervious to water, bears hard rubs and knocks, and is therefore highly fitted to cover that part of our bodies—the feet—which, generally speaking, have the most work to do.

We shall describe the materials which he employs, before explaining the different processes of his trade; and may remark that his success depends on the action of a substance called "tannin," which, by uniting with a part of the skins of animals, changes those skins from their soft, flabby texture, into a solid, tough, and enduring material.

The chief animals whose skins are converted into leather are the ox, buffalo, cow, calf, sheep, horse, dog, seal, &c., although many others would no doubt answer the purpose. The chamois, a species of goat, affords us the soft leather called "shammy;" whilst the kid, rat, dog, and many small animals, provide us with skins for gloves. Even the human skin has been tanned, and, like all others which have undergone this process, it becomes harder, thicker, and impervious to wet.

Besides the skins, the tanner requires certain vegetable matters which will afford him the "tannin," of which we have just spoken. Oak-bark has, until lately, been chiefly used, and is still employed in large quantities. In collecting the bark, after the tree is cut down, a slit is made, lengthwise, from the top to the lowest part of the stem, and the bark is then removed in pieces of about three feet in length; the branches are also similarly cleared, and the produce is made into bundles after being carefully dried.

Cork-tree bark is also used in tanning, and is the product of a kind of oak. The bark of the willow, Spanish chestnut, alder, larch, &c., are also employed; and that of the birch affords a peculiar smell, to which the odour of Russian leather, used for purses, pocket-books, &c., is due. Many other trees afford barks which the tanner can use, and even the common heather or ling of our moors has been found capable of tanning skins.

Sumac, the leaves of a tree grown in the South of Europe, is very valuable, as is also catechu, or cutch, which is a kind of extract obtained from an East Indian tree. Terra Japonica, which much resembles the cutch, is largely used by tanners ; valonia, or the acorn cups of a kind of oak; divi-divi, the pods of a South American tree; myrobalans, the fruit of an Indian tree; and boomah-nuts, all contain much tannin. Some species of resin, as kino, obtained from the East Indies, Africa, and Australia, complete this list of tanning materials.

And now a word or two about the *science* of tanning. If our young friends will procure a little common size, such as is used by plasterers, and dissolve it in warm water, then add to it a little tincture of galls, which may be got of any chemist, they will find that a powder-like substance falls down. This arises from the tannin in the galls uniting with the gelatine or jelly-like matter in the size, and the substance which falls down is *real leather!*

This simple experiment explains all that the tanner does with the skins. They contain gelatine, and the tan-liquor from oak-bark supplies the tannin, so that, after the skin has been soaked sufficiently long, all its gelatine becomes converted into a solid, and then the skin is turned into leather.

We now proceed to describe the process of tanning. The skin, or, as it is generally called, the "hide," has the horns and all superfluous matter removed; and its inside surface is scraped with a knife, all the flesh, &c., being carefully cut away. The hair is removed by soaking the hide in water containing lime, and the skin is afterwards well scraped to remove all the hairs from its surface.

Meanwhile the tan-pit has been prepared by soaking some of the materials in tanks of water sunk into the ground. The hides are then put in singly, and a layer of oak-bark or of other substances is strewed on it; another hide is then put in, and so on until the pit is full. The skins, after some time, are removed into other pits which contain a stronger "ooze," as the tanning liquid is called, and so the latter gradually soaks in, and the gelatine, being acted upon by the tannin, is completely turned, with the skin, into leather.

This is a long process, often taking from twelve to eighteen months. Sometimes strong acids are used in place of the ordinary tanning materials, but these, whilst they shorten the process, generally spoil the skin, and make it brittle. Hence the reason that cheap shoes made of such leather do not keep the wet out, and they crack after being worn for a short time.

After the tanning is completed, the hides are removed from the pit and hung up to dry. They are then beaten or rolled, to render them of an even texture and surface, and become ready for the processes of a trade carried on by

THE CURRIER.

The operations of the currier are intended to fit the leather for the use of the shoemaker and other tradesmen. On receiving the hides from the tanner they are wetted, and well beaten with a wooden hammer, so as to make them pliable. To render them of equal thickness throughout, they are scraped and shaved, so that the whole hide may be put to use. By rubbing with grooved pieces of wood, &c., and constantly beating, rubbing with tallow, &c., and stretching the leather, it becomes soft, and it is then blacked on one side, so as to fit it for the bootmaker.

The thick skins, as of the ox and other large animals, afford the soles and heels; whilst the thinner kind obtained from the sheep, goat, dog, but especially the calf, are converted into "upper leathers" of boots and shoes.

There are some kinds of leather applied to fancy, ornamental, or peculiar purposes, which are not produced by tanning after the method we have explained. Thus the shammy or *chamois leather*, after the hair, &c., have been removed by lime, is prepared by being beaten with oil by heavy mallets in a machine called a "fulling stock;" and thus the oil becomes the preservative, and renders the skin beautifully soft. Kid skins for gloves are prepared by means of the yolk of eggs and alum; and by being repeatedly drawn over a board, they acquire great softness. This operation is called "tawing."

Goat skins afford the morocco leather used for purses, binding books, &c. They are tanned by being soaked in a bag in water containing sumac, the nature of which we have already described at page 50, when speaking of the materials used by the tanner. The leather is then dyed, and afterwards well rubbed to render it pliant; the grooves in the wood-tool used for the purpose giving those peculiar marks by which morocco leather is known. Sheep skins split into two thicknesses are often substituted for goat skins in producing inferior qualities of this article. "Shagreen leather" is produced by pressing seeds, as of mustard, &c., into the skin obtained from the back near the tail of horses, mules, &c. It is first wetted, then scraped and stretched on frames; and being dried while the seeds are in, it retains their form on its surface. After dyeing it is polished, and then becomes fit for working into various ornamental articles. Russian leather, so called, is tanned with birch bark, and, as we have previously stated, owes its peculiar smell to the oil which that bark contains.

The various uses of leather, besides those we have named, will be mentioned under the head of the "Shoemaker," "Saddler," and other trades.

Having thus described the processes by which some of the leading raw substances, as cotton, flax, wool, silk, skins, and fur, or hair, are converted into articles of attire, we shall deal with some trades in which the manufactured article is used as a first material. These trades we shall find are really dependent on those already described, and we shall avoid any repetition of processes previously explained, and depend on our readers having fully mastered the details that have been afforded. Of these trades we shall commence with

THE SHOEMAKER.

In our description of the tanning processes by which skins are converted into leather, we stated that the hides of the ox, buffalo, and other large animals, being thick, were fitted to become the sole and heel of shoes and boots, whilst the thin skins, as of the calf, sheep, goat, &c., formed the upper leathers, or that portion which covers the top of the foot.

The usual way of forming the upper leather is to cut out a piece of calf, kid, or other material, of such a shape as to be a little larger than a "last," which is a piece of wood so carved out as to be of the same form as the foot that is to be fitted. A small portion is left as a margin beyond the actual size, so that it may serve to receive the welt, or that portion of the shoe or boot to which both the upper leather and the sole are attached. This being done, holes are made, at small distances apart, throughout the rim of the leather, and another but thicker piece is taken and fitted to the sole of the last, which will form the welt. Through this, holes are also driven by the awl, and the workman, taking a piece of hempen thread (see page 20), rubs this over with a mixture of pitch, wax, &c., called cobblers' wax: this answering the purpose of preventing the thread from fraying away, and of making it slip easily and adhere tightly to the holes in both the welt and upper leather. The thread is passed through the holes of each, and, being pulled tightly, fastens the two together. The sole is fastened to the bottom of the welt by means of steel or brass pins, but of late years wooden pegs have been much used. They have the advantage of wearing slowly, and when wetted, they swell, and so are not liable to give way, or to leave the leather. The seams of the sides of boots and shoes are neatly sewn together, and the operation is called "closing." It is generally done by women, who are called "boot closers," but recently machines have been applied to this purpose, which do the work much cheaper and more neatly than the human hand.

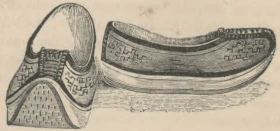
The heels and soles are made of leather obtained from the thickest part of the hide, and shoes and boots are either single or double soled, according as they have one or two pieces of leather forming the sole. Shooting, fishing, and clumped sole boots are made very thick, so as to resist the wet to which the wearer of them is exposed. The best "English butts," that is, the thickest part of English-tanned ox hides, are used. The heel consists of two or more pieces of this leather fastened with long steel nails, or even screws. Amongst other novelties are "revolving heels," which are not fixed completely to the sole, but only so that they may be gradually turned round as one part is worn away. This is a great advantage to many persons who wear one heel far faster than the other in walking.

The soles of boots and shoes are often made of gutta percha, which is fastened on by first drying the original leather sole, then roughening it by a file, warming it, covering it with a solution of gutta percha or India rubber in coal naphtha, and then pressing on the gutta percha sole, which has been previously warmed to make it pliable. Pegs should be driven in all round the edges so as to prevent the gutta percha from springing away, which it is apt to do as it cools and hardens. Gutta percha is a bad conductor of heat, and perfectly impervious to moisture, and therefore forms a perfectly waterproof and warm sole. India rubber fastened in strips diagonally across a leather sole is also very useful, as it keeps the feet dry, and also tends to prevent the feet from slipping when walking over a very smooth surface, as of snow and ice.

The upper leathers of shoes, &c., are kept soft and waterproof by frequently rubbing them over with tallow, or other animal grease; and if they are polished before being greased, they can easily be polished afterwards. The leather sole may be also rendered waterproof by occasionally smearing it with a mixture of tallow and tar.

By folding a piece of writing paper to the size of the sole of the foot, and putting it inside the shoe, so as to rest on the sole, the feet may be kept warm and dry in the most rainy weather. Cork and woollen soles are made for the same purpose, but are of no greater benefit than the paper we have recommended, and which we have used with much advantage for many years past. Each depends on its being a bad conductor of heat, and so prevents the chilling of the foot. Our young readers should remember that cold and wet feet are the cause of a great part of the illnesses common amongst us.

We have not space to describe the numerous kinds of fancy shoes and boots used for dancing, as slippers, &c., and can only glance at the kind used in former days. Then the upper part of the foot was often left uncovered, and merely a kind of sole was used, which was fastened round the ankle with a kind of band. In many parts of this country, and on the Continent, wooden soles are used in place of leather, for they protect the feet from wet by raising them high from the ground. Pattens, which have gone out of fashion, and clogs, which are almost obsolete, answer the same purpose. At the present time *goloshes*, made of sheet India rubber, are most employed as an extra protection from wet.



For Men.

For Women.

Plate 6.—Chinese Shoes, p. 67.

The shape of shoes, &c., has constantly varied. Sometimes the toes have been so lengthened as to have been brought round in a curved form and fastened at the knee. Sometimes the peak projected a long way from the toe—a custom common in the time of Richard II. In the time of Edward IV. shoemakers were fined if they made the peaks more than two inches long; and subsequently they ran to the other extreme in making them so wide that a fine had to be imposed if such were produced of a greater width than *six inches*. High heels afterwards came into fashion, and these were carried to such an extent as to raise the wearer about eighteen inches higher from the ground than was natural. The Chinese, even of the present day, have the cruel custom of making the women wear small shoes from their earliest age, until their feet become unnaturally cramped. Some years ago a Chinese urged us to visit his country, and, as an extra inducement, promised to find us a wife who should have the *smallest* feet of any woman in Canton. This he said as the greatest recommendation he could find in favour of the women of his nation.

THE FURRIER.

The trade of the furrier is of itself scarcely worthy of lengthened description, because he only exercises a selection of the skins, and gives them out to work-folks, who first cut them into suitable pieces, and then neatly sew them together. But a description of the various kinds of furs that are used, and the animals which supply them, will doubtless be very interesting to our young readers; and this we shall accordingly furnish, together with some account of the method of preparing them, and their subsequent conversion into articles of dress.

All the animals usually sought after for the sake of their furs are inhabitants of either cold or temperate climates. The reason of this is obvious, for man uses the very article which is given to the animal to enable it to resist the cold of the climate of which it is a native. Fur is composed of two parts—namely, wool and true hair. Of these the soft, woolly, or down-like portion forms an inner coat on the external surface of the skin, and is short and fine, whilst the hairs, which are much longer, serve to shield the inner coat, and so to keep the animal entirely protected from the cold. The hair is frequently shed at intervals by some animals.

The warmth of fur depends, like that of the feathers of birds, on the quantity of air it can contain; for air is a very bad conductor of heat so long as it is kept out of motion. Thus, on a still day we feel far less loss of heat than on a warmer day, when the wind blows hard; and we have heard celebrated Arctic navigators say that they have not felt the least inconvenience from the greatest cold, so long as the wind did not blow; but when the air was comparatively warm and boisterous, they were immediately frost-bitten. It is to this enclosing of the air alone, therefore, that furs owe their warmth; another proof of which is, that if they are well wetted, they cease to be useful or warm articles of clothing. Having thus explained the cause of the warmth of fur, we shall now describe the animals from which it is obtained.

The most valued kind is that called *sable*, which is the skin of a small animal of the marten kind, and a native of Siberia, in the North of Asia. In our own country we have also some species of the marten, which afford us an inferior kind of fur: they are respectively the common and pine marten. In America another species affords also a kind of sable.

The mink, weasel, polecat, ferret, and the stoat or ermine, all belonging to the weasel tribe, provide us with fur skins. The valuable fur called *ermine* is the winter skin of the stoat, a British animal: its tail is black, and forms the black patches seen on the fur. We may here inform our young friends that the hair of many animals turns white in winter, as is found in species of the hare even in our own country. This is a merciful provision, for of all colours white is that which least favours the passage of heat from the body. Hence this assists in keeping the animal warm, whilst its colour, being similar to snow, protects it frequently from becoming the prey of other animals and men.

Otters, which are very common in Canada and in Europe, furnish an excellent fur. The Canadian otter has a funny method of amusing itself during winter. A number of them will select a steep bank covered with snow, and, mounting the top, they slide down into the water, then rushing up again for a fresh slide. Sometimes they keep up this game for a long time, apparently for the sole purpose of amusing themselves, just as boys do on ice.

In the Arctic region the Arctic bear and fox afford furs. In the summer the skin of the latter is of a dark brown colour: it, however, becomes quite white and thick as winter comes on, and its fur, like that of its companion, is an excellent protection from the cold. Its skin has fortunately no smell, like that of the common fox.

The beavers, natives of the northern regions of Asia and Africa, afford an excellent fur, which formerly was much used in making hats. These animals build large dams or houses of the stems of trees, covered with mud to keep the sides dry. The fur consists of two sorts—a coarse long hair and a downy kind beneath it, the latter being that which is most preferred. The coypu, an animal of the beaver kind, but much smaller, and a native of South America, furnishes a good fur, of which many hundreds of thousands are annually sent to this and other countries.

Amongst the skins of large animals are those of the buffalo, leopard, deer, elk, and wolf: the racoon and coati, which both belong to the bear kind, and are natives of the warm countries of America, also supply valued furs. The wolverine or glutton, so called from an erroneous idea of its eating powers, belongs to the badger tribe, and has a skin of a brick brown colour, used as a fur.

The cat family, including the lynx and the common cat, with many others, have skins used as furs. Our domestic cat is often cruelly skinned while alive, under the idea that its fur is then more valuable. The skins of many kinds of our domestic dog also afford "furs."

The musquash, a member of the rat family, and a native of Canada, furnishes the fur which goes by its name. The chinchilla, whose fur is very thick and soft, is of a gray colour, and has an elegant appearance. It is a native of Chili and Peru, where it lives in the mountains of the Andes, in caves of the rocks, only venturing abroad at night time. The mountain viscacha is a native of the same regions, and is a larger animal than the chinchilla; but its skin is not so highly valued. The skins of the mole and the rat, animals well known in this country, are often used as furs for small articles; and the hare and rabbit afford us furs often used in place of the more expensive kind.

The squirrel, a native of our own and other northern countries, has a fine gray coat in winter; and these animals are killed in great numbers for the sake of their skins. They chiefly feed on nuts, and may be seen in abundance in our woods. They are elegant little creatures, and actively spring from branch to branch in the trees. They make a nest for their young, of moss, leaves, &c. The tail is large and bushy, and materially assists the squirrel in his leaps. In America the squirrels abound to an enormous extent.

The skin of the opossum, an animal common in all parts of America, excepting the cold climates, affords an excellent fur, of which rugs that are very warm may be made. The kangaroo, an Australian animal, and of a similar kind to the opossum, also has a valuable skin used as a fur, and when tanned, and the hairs removed, it forms a good material for boots and shoes.

Amongst the inhabitants of the sea, the seal is about the only one whose skin is used by the furrier. It is extremely valuable, and fetches a high price when made up into mantles and other articles of ladies' dress.

We have thus described the chief skins used as furs. The coarser kinds are mostly retained in the countries where the animal producing them exists; and it is only the finer sorts, and generally those of small animals, which are sought after in this country.

The skins are cleaned and washed with a solution of alum, &c., to preserve them; but they are liable to the attack of the moth, which is sometimes prevented by means of camphor, pepper, &c., but best by constant beating, which drives away the insect and shakes out its eggs.

In making up the furs into muffs, tippets, boas,

&c., the inside is lined with cotton or wool wadding (see page 15), so as to give the article a bulky appearance, and also to add to its warmth-preserving powers. The sale of fur articles chiefly occurs near and in winter. The furrier has to prepare his goods a long while beforehand. He generally does this during the summer months, and so accumulates his stock for sale at the end of the year. The amount of trade is very uncertain, for during a warm winter but few furs would be required, and hence the business is one of some little risk, especially should the fashions change. In our boyish days ladies wore fur tippets reaching to the waist, boas that touched their feet, and muffs almost big enough to hold a child three years old; and we have pleasing remembrances of the good things that used to reach home in the inside of the muff, and which we generally claimed the right of clearing out.

In Russia and other cold countries the skins of some animals are sewn neatly together so as to make greatcoats, resembling in shape those made of broad cloth. They are exceedingly warm, as we can testify from using one which was made a present to us by a Russian gentleman; and they also completely keep out rain if they have been properly prepared.

THE GLOVER.

The materials used by the glover have been mostly described under the head of "The Tanner," so far as leather or kid are concerned; and we shall reserve any description of cotton, woollen, and silk gloves until we describe the trade of the stocking-maker or hosier, because they are made in a similar manner to the articles produced by the stocking-frame.

The skins of the kid, rat, and other small animals, serve to make the fine sorts of "kid" gloves. The skins are cleared of hair, &c., as described at page 60; but instead of being tanned with oak-bark, and other such materials, they are prepared by working them with alum and the yolk of eggs, which render them soft, and fitter for the purpose to which they are to be applied. The skins are dyed to the requisite colour by using liquors already named whilst we described the art of dyeing. They are then cut into the required shape for the fingers and hands, and are neatly stitched, either by women or by a machine. Dog-skin, calf-skin, doe-skin, and many other materials are also used, these articles being made strong for the use of drivers and others.

"French kid" gloves are generally the most esteemed; but in our own country excellent articles are made, which often are much more durable than the foreign ones. Dundee, for example, has been long noted for gloves; and many towns in England have acquired a good reputation, and, in some instances, given names to the gloves manufactured there.

In cold countries, gloves are made by sewing the skins of animals with the fur on, and such articles are of course very warm. They are almost absolutely necessary in Greenland, Iceland, and the North of Europe, and even with us they are occasionally worn during severe winters.

THE HATTER.

The coverings used for the head have, perhaps, of all other articles of attire, been the subject of strange fashions. In the hot countries of the East the turban is worn, which consists of a fold of white or printed cloth wound carefully and tastefully round the head. Savage nations are generally blessed with a large "head of hair," but this they frequently adorn with feathers, &c., and occasionally plaster it thickly with mud and dirt. The Persians wear a high cap made of a light material; whilst in the South of Europe the Greek cap is frequently worn, fitting tightly to the head. In most parts of the Continent, as Germany, France, &c., the black hat, common with us, is fashionable; but of late years caps made of cloth, straw, hair, and other materials, have been largely worn. In cold countries, as Lapland, Russia, &c., fur caps are mostly used, as is also common in Canada; for such articles are warm, and therefore suitable for the climate.

The hat commonly worn is certainly by no means an elegant contrivance; and, indeed, it has nothing to recommend it except the fashion which keeps it in use. Formerly hats were made entirely of the fur or hair of the beaver, or animals affording a similar material, such as the musquash, a species of rat; the coypu, belonging to the beaver tribe; the hare, rabbit, &c.; all of which animals we have more or less described in connection with the fur trade.

"Beaver hats" were thus made:—The fur was first shaved from the skin of the animal, and sorted so that the fine hairs were separated from the coarse, the former being chiefly used. The fur was then opened out, by causing it to fall on the string of a kind of bow, kept in constant vibration—a process called "bowing" the fur.

This was afterwards "felted" together (see page 26), so as to form a slightly adhering mass; and by subsequent pressing, rolling, heating, &c., it became completely "felted," and so produced the body of the hat. After being dried, it was covered with a resinous mixture, which adhered to the surface, and formed a sticky coat, on which the beaver fur was spread. The whole was then shaped over a block into the form of a hat, and the beaver fur was sheared or cut so as to produce an even nap. The dyeing process followed; and by subsequently working this felt on a proper block, the final shape was given to it. Beaver bonnets worn by ladies are still made in a similar manner, the shape of the block, of course, being suited to the form required.

"Silk hats," however, have now completely taken the place of beaver for the use of men; and, perhaps, so much is this the case, that none of our young readers have ever seen one of the beaver kind. The following is the method in which our ordinary hats are made:—

First the "body" of the hat (that is, the inside, solid part) has to be made, and this is done by shaping stiff brown paper, felt, willow, hair cloth, or any of a number of other suitable materials into the form which the hat is to assume. This body is then covered with a solution of shell-lac, a resin-like substance, which gives the "body" stiffness, and serves also to hold the silk firmly on its surface.

The outer covering is made of silk, manufactured in such a way that the edges of the fibre stretch outwards to form the "nap" of the hat. It is sewn together in pieces at the top, but not at the sides, for the seam would show, and make an unseemly mark. It is then passed on to the body of the hat, and by passing a hot iron over it, the lac or resin on the body is melted, and so the silk adheres. The edges at the side are neatly brought over each other obliquely, and adhere—the art being to conceal as much as possible the joints which they make. This is not readily seen when the hat is new, but is discovered gradually as it is worn, and exposed to wind and wet. By careful use of the hot iron a fashionable shape is given to the hat, the body of which, as we have already seen, being pliable under the action of heat.

The inside is then lined with some light material, a piece of leather being sewn on that part where the head will touch. This prevents the grease of the head from spoiling the appearance of the outer silk. Round the rim of the hat a piece of silk binding is fastened, and the ends are attached by a buckle, the band being intended to hide the place where the covering of the rim and hat join.

White hats are made of wool, felted and fastened on a suitable body by means similar to those already described: white silk plush is also occasionally used. The advantage of a light over a dark-coloured hat for summer wear, arises from the fact that the white absorbs heat very slowly, whilst the dark or black colour does so very quickly, and so renders the head hot. To prevent this, "ventilating hats" have been made, which, by a hole in the crown, neatly concealed, allow of the egress of hot air accumulating inside the hat, and which often causes severe headaches in hot weather.

Caps are sometimes made of wool, which has been felted in a precisely similar manner as that we described in producing cloth at page 28. Cloth caps are manufactured very frequently from the laps of old coats, &c., and a large trade of this kind is carried on in some parts of London. Formerly boys wore a very light cap made of horse hair woven into a kind of cloth; but these have been almost entirely superseded by straw hats, which we shall describe in connection with straw-plait and ladies' straw bonnets.

STRAW-PLAIT FOR BONNETS, &c.

Of late years the fashion of wearing straw bonnets has not been very common; indeed, a straw hat is much more commonly worn in summer time by the other sex. It will therefore not be necessary that we should do more than give a general description of the mode of their manufacture. It is one of the few trades in which machinery has not been of any service in helping the worker.

The material is the straw of some species of wheat plant of the bearded kind, and usually grown for the purpose, either in this country or in Italy; Bedfordshire having been long noted for the trade with us; whilst Tuscany has been always celebrated for the beauty of the straw and the plait which it has produced.

Our young friends will have noticed that the straw of wheat has numerous joints or knots, termed, in botany, nodes. The straw-plait collector cuts the straw between these joints, so as to avoid them. The nearer the straw is to the roots the coarser it is, and hence the best straw-plait is that which grows nearest to the ear of the plant. The material is thus obtained of various finenesses or qualities, and after drying and partially cleaning, it becomes fit for the plaiter.

The operation of plaiting is carried on by first tying together a number of straws at one end. They are then interlaced or plaited, fresh straws being pieced in as required. Thus a long ribbon is formed, which is the "plait" of which the hat or bonnet is afterwards made.

To form either of these articles a ribbon is taken and wound round a block, the edges being sewn together by thread. By these means any form or shape may be produced; and thus hats, caps, bonnets, &c., are formed. The value of these depends on the fineness of the straw; and in our younger days Leghorn bonnets fetched an enormous price, far exceeding that asked for the best silk and other kinds sold at the present time.

Straw-plait is bleached by means of burning brimstone. The bonnet or other article is moistened with water, and some flowers of sulphur are placed on a hot iron, so that they may burn slowly. The straw-plait articles are placed over the brimstone, generally in a closed chamber, and as the fumes arise, they become bleached or whitened. If required of any particular colour, they are dyed just like cotton, &c., as described in the article which we have devoted to the dyer's trade.

Other materials of a vegetable nature are used for making bonnet-plait, as, for instance, the twigs of the willow, thin cane, &c. But such, at the present time, generally form the body on which silk and other materials are stretched, and therefore do not need a separate description.

THE LACE-MAKER.

There are so many varieties of lace, most of which are called after the names of places where they are chiefly produced, that it would be impossible for us to describe to our young readers the methods used in their manufacture. Amongst these are "Brussels," "Mechlin," "Point," "Valenciennes," "Honiton," &c. We shall therefore content ourselves with a general description, so that an idea may be gathered of the various processes that are followed.

In former times, as at present to some extent, lace was made on a kind of cushion called a "pillow"—hence the term "pillow lace." The pillow is covered with parchment, and on this the pattern is pricked, pins being fixed in the holes. The thread intended to form the lace is wound on to small bobbins, and the thread is twisted round the pins, and the bobbins in and out of each other, so as to form the net on which the pattern is to be worked. The pattern is produced by the intertwisting of the threads on the bobbins on this net, and varies according to the taste and skill of the workers, which are always women, their delicate fingers being required for this kind of manufacture.

But net produced in this way is very expensive, owing to the length of time required, and hence arose the invention of the bobbin net machine, which does by machinery what the fingers of the worker had previously performed, only far more exactly, and much more rapidly.

It is almost impossible to describe the construction of this exceedingly complicated machine, without the aid of one, or a model. Its operations consist in twisting one set of threads round another in different directions. Two sets of threads, for example, cross each other, forming little open squares, and a thread wound on a little bobbin is caused to pass in and out of these threads diagonally. The upper threads are kept stretched, whilst those on the bobbins are passed in and out between them, and twisted round them, but the former have also a sideways motion like the pendulum of a clock. Many thousands of bobbins are employed at once on a machine, depending on the width of the net which has to be made.

This description applies to plain net only; and if our young readers will unravel a piece, we fancy they will be able to comprehend the manner in which the machine does its work. When patterns are worked in the net, as in blonde, &c., the processes become still more complicated; and such defy our power of description on paper.

When the net is complete, the little fibres which extend from each thread are burned off, by passing the web over a row of gas jets slowly, but continuously, for if the net were to stop for an instant it would catch fire. This operation is termed "gas-ing." It is then bleached or dyed, in a manner similar to that pursued with calico (see the articles "Bleacher"

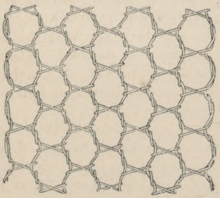


PLATE 7.—BOBBIN-NET MESHES, p. 82.

and "Dyer," previously), and afterwards dressed by a mixture of gum or paste. On being dried it is then fit for the purposes of trade.

The lace trade is largely carried on in various parts of this country, but especially in Nottinghamshire, which has long been noted for the manufacture.

In Glasgow a large trade is done in "sewed muslins;" but these are chiefly produced in the North of Ireland, where many thousands of young women get a living by embroidering muslin by hand. This article, when finished, forms the collars and cuffs commonly worn by ladies. In this branch, however, machinery is being introduced, which, whilst it may lessen the demand for hand labour, will no doubt make the "muslins" much cheaper. These girls depend, even at the present time, on the fashion of the day, which, if it were to change, would spread ruin in thousands of families.

Formerly the patterns both on lace and muslin had little pretension to being considered as works of art; but the schools of design, now established in all our large towns, have fostered taste and educated the eye of the operative. To such an extent has this been carried, that a good design produced by the workman will often fetch him a large sum of money, so true it is that there are "no gains without pains."

Tapestry work, which was formerly held in high repute, is carried on much in the same way as that adopted in working or embroidering muslin. At the

Exhibition at London, in 1862, some splendid specimens of the art were exhibited in the French department, and so beautifully were they done, that, on first seeing them from a little distance, we mistook them for oil paintings. The Cartoons of Raphael, now in Hampton Court Palace, were drawn by him as patterns for the tapestry workers at Arras, and intended to adorn the Vatican at Rome.

THE HOSIER.

One of the most useful articles of dress are those which cover the feet, and preserve them from cold. Shoes and boots, which form the external covering, we have already dealt with under the head of the "Shoemaker's" trade: we must now devote a short space to describe the manufacture of socks, stockings, and such woollen articles as gloves, shirts, &c., that are manufactured in a similar way.

Some of our old paintings, &c., give us an idea of the kind of hose used by our forefathers. Those worn by the Anglo-Saxons generally extended as far as the knee, and were outside, just as gaiters are used at the present day, and not covered with other garments, as now practised. In the time of Chaucer the poet, it was customary to wear hose of different patterns, one on each leg. Eventually hose degenerated from its use as an external article of dress, and became the socks and stockings of modern times.

Various materials are employed for the manufacture of hosiery, as for instance cotton, wool, cotton and wool mixed, forming "merino;" lamb's-wool, silk, and the long hair of other animals. When wool is used, the long-stapled kind is preferred, as we have already explained when speaking of these wools, their preparation, &c., at page 25, in our article on "Wool."

The early method of making hosiery was by means of needles worked by hand, and in many parts of this country, especially at small farms in the North, the women employ their leisure time in knitting the stockings of the household, the wool being generally the produce of the sheep fed on the land of the farm. Articles thus produced are called "hand-knitted," and they are generally much liked, although somewhat expensive, because they wear longer than those produced by the stocking-frame. The wool is used either in the gray, as cut from the sheep, dyed and of one colour, or occasionally two different-coloured worsteds are used, by which a checked appearance is produced. In the Shetland and Orkney Islands, with many other islands on the West of Scotland, some beautiful articles in stockings, shirts, ladies' falls or vails, &c., are produced by the Islanders, or Highlanders as they are also called.

But the supply of hosiery by hand work would be far too small for the present wants of our people, and over two hundred years have elapsed since attempts were made to produce such articles by machinery. This want led at last to the invention of the stocking-frame, now so extensively used to make hosiery, gloves, and other knitted articles.

It would be impossible to describe on paper, or even by a drawing, the construction of a stocking-frame, for its parts are too numerous and complicated for any but a good mechanician to understand. We may remark, however, that by a peculiar arrangement of needles, furnished with a loop or hook at the end, the thread is so interwoven in loops, like chain-work, as to form one continuous piece. It somewhat resembles the process of net making, but only *one* thread is used throughout, so that, if it should break in any part, the whole work soon becomes unravelled. Hence the speed with which holes in stockings, knitted gloves, &c., enlarge, unless mended immediately. In such cases the old proverb is true indeed, that "one stitch saves nine." The persons who perform the work are called "frame-work knitters," and large numbers are employed, for stockings or socks of some kind or other never go out of fashion.

Cotton hosiery is largely made in Nottingham, Leicestershire, and adjacent counties, whilst some parts of Derbyshire, especially Derby itself, is noted for its manufactures of silk hose. But like every other trade, that of hosiery is gradually extending itself, and will soon cease to be distinguished as of any particular place.

It is only just we should remark, that although it has been attempted to claim the honour of inventing the stocking-frame for a Frenchman, there is every reason for believing the entire credit is due to William Lee, of Cambridge. He was a native of Woodborough, in Nottinghamshire, and it is said that he was led, in the year 1589, to attempt the invention, in the hopes of diverting the attention of his lover, who seemed to be fonder of her knitting than of himself. In his early attempts he met with neither success nor encouragement, although he appealed to Queen Elizabeth. At last, however, the invention made progress, and now affords means of work to thousands of our operatives.

THE TAILOR AND DRESSMAKER.

THE SEWING MACHINE.

Our preceding pages have afforded an account of the methods used in manufacturing calicoes, woollen cloth, linens, silks, &c.; and these form the materials for the trades of the Tailor and Dressmaker. Of the "art and mystery" of these trades we can say little, for they simply consist of cutting out the materials according to pattern, which depends on the fashion of the day or the taste of the wearer. The "tools," if we may so call them, are simply needle and thread, the latter of which has been already treated on in connection with cotton, silk, &c., and we shall reserve our description of needle and pin-making for our chapter on Trades connected with Metal Manufactures. There is, however, a machine now largely used by tailors, dressmakers, and in our homes, which deserves a description here; it is the Sewing-machine, which has now so largely replaced hand-work, and saved many a poor needlewoman from the drudgery of "Stitch, stitch, stitch," as Hood sang, when describing the miseries of that ill-paid and hard-worked sisterhood.

It will be, however, rather a difficult matter to so describe the sewing machine as that our young friends who have not been used to machinery will fully understand us. In sewing, after the ordinary fashion by hand, the needle is pressed through the cloth alternately, so as to form a stitch which appears on both sides, and this is done by the finger, covered with a thimble. In the sewing machine, of course, the fingers are not used, but two small rollers, covered with vulcanized india rubber, perform the same office. These, as well as the other parts of the machine, are worked either by a wheel turned by the hand, or by means of a treadle similar to that we see in the knife-grinder's machine, and which is worked by the foot.

When the thread is made to pass through the cloth, a kind of shuttle or bobbin is caused to slip into the loop produced by it, and this shuttle, on returning, forms a stitch something after the fashion of the twisted part of a piece of net. Perhaps we may illustrate the result by comparing the position or form of the "stitch" to that produced by making a kind of link with the forefingers of each hand so bent round each other as that the inside of one finger, lengthways, shall catch hold of the breadthways of the other finger. A similar appearance is presented when we catch hold of a loop of string in holding a parcel by the finger.

By thus interlacing the thread of the needle with that of the shuttle a seam is produced; and so ordinary sewing is effected by the machine in place of by the hand. By such means shirts, collars, stays, mantles, dresses, coats, waistcoats, trousers, caps, bags, sacks, harness, and even boots and shoes, so far as the upper leather is concerned, are now made; besides many other articles too numerous for us to mention. Seaming, hemming, gathering, and binding, are also done, and the work is far neater and stronger than that done by hand.

The sewing machine has been made of many different forms, and is not only used by ordinary workers, but even in our own houses it is now a common case to see the young ladies "working at the sewing machine;" and we are inclined to fancy that many of our young lady readers will prefer it to the old needle fashion, for it does not make those unsightly marks which used to be produced on the forefinger by sewing.

We have thus given a description of the various trades which are followed in this and many other countries in producing clothing for our feet, bodies, and heads, and the various processes by which cotton, flax, silk, wool, skins, &c., are prepared for that purpose.

Man has indeed "sought out many inventions," and his fancy, although at times amusing, has the advantage of giving employment to many thousands who might otherwise scarcely find a living. But "fashion," although sometimes ridiculous, has the advantage of calling out the energy and inventive powers of the workman, and so, like many other affairs, has its use as well as its abuse. In our younger days there were some very curious fashions, both for dresses of ladies and gentlemen, which would seem very laughable to the young of this day. It is, however, more than likely that our young friends may, as they get older, laugh at that which they now admire, and so condemn their present fancies, when others yet to be laughed at shall become fashionable. We may all remember reading that, some two thousand years ago, our land was peopled by those whose fashion was that of painting their bodies, and clothing themselves with raw hides or skins; so that, after all, *we*, as a nation, were no better off than many of the inhabitants of *present* savage islands!

CHAPTER II.

TRADES CONNECTED WITH THE SUPPLY OF FOOD, DRINKS, ETC.

In the first chapter we have endeavoured to explain to our young friends the sources whence the raw material is obtained, and the mode of manufacturing it into various articles of clothing. We shall now have to ask their attention to another, and not less interesting subject; it is that of the sources of our food, &c., and the trades followed in preparing it for our use.

But before we enter on these subjects we shall make some remarks on the nature of food, and show the reason and necessity of its use. Just as we have noticed in respect to clothing, that there is a great variety, so we shall find that food, in its nature and properties, varies according to the climate, both in respect to its growth and use.

Let us glance for a moment at the different kinds of food used in the various countries on the face of our globe. In Greenland, Iceland, &c., we find the natives exceedingly fond of oils,—indeed, an Esquimaux prefers the coarse train oil, which *we* use only in common lamps, to the greatest delicacy that we can offer him. We heard an anecdote some years ago from an Arctic navigator, to the following effect:—An Esquimaux having been invited into the Commander's cabin, tea, coffee, wine, brandy, &c., were placed before him. Not used to these drinks, he refused them all; but seeing a basin containing some oil that had been used to clean some brass article in the cabin, he put the vessel to his lips, and drank it off with the greatest relish, and even licked out the inside, so that he might not lose a drop of the liquid. Another Arctic traveller told us that he was continually losing tallow candles from the sledges, and at last he detected some of his men—English sailors, not Esquimaux—actually *eating candles.* The reason of these singular tastes we shall presently explain.

In our country, most parts of France, Germany, &c., bread forms the chief food, together with a moderate amount of meat and vegetables. In Italy, Spain, Greece, &c., lighter food is used as bread, especially maccaroni, &c. In the first-named country fruits are also universally employed. Crossing over to Africa, we find that the date, a fruit of a species of palm, is the chief food of the natives; whilst in India and China rice feeds the greater proportion—perhaps nearly half of the human race.

Now, why does this difference exist in food used by natives of different countries? It is easily explained, as we think our young readers will soon find, if they carefully think over what we are about to say to them.

Food serves three purposes chiefly. The first is to *give heat* to our bodies; the second is to *give us flesh, fat, and muscle;* and the third is that of *producing the bone*, which is the frame on which the rest of our bodies is placed or hangs.

Let us first consider how food gives heat to our bodies. It seems a most surprising thing that bread, sugar, arrow-root, &c., should produce the heat of our bodies, after we have partaken of those articles as food. The fact is, they serve precisely the same purposes as the coals do for our fires. They actually *burn* in our bodies, and, what is still more wonderful, they contain precisely the same substance as coal—that is, charcoal, or, as chemists call it, carbon. This is easily proved, for if we hold a crust of bread near a fire, it gradually toasts; if we burn it, we turn it black, and the black substance thus produced is the charcoal of the bread, just as coke is the charcoal of coals. Another way of showing that charcoal is contained in food is to dissolve as much sugar as possible in a tea-cupful of hot water. The syrup is then to be poured into a large tumbler, and some strong sulphuric acid added, when the liquid will get hot and froth up, producing a tumblerful of *black charcoal.* This proves that even that beautifully white article, loaf-sugar, contains *charcoal.* If arrow-root, potatoes that have been cooked, bread, &c., are treated in a similar way, they will all afford charcoal.

Having thus explained to our young friends how charcoal may be produced from such articles of food, let us now trace its progress through our bodies, and show how it burns, and affords us heat.

When our food reaches the stomach, it is gradually dissolved, and passing through various changes, becomes converted into blood. This blood has a dark colour till it reaches the lungs, owing to the great quantity of charcoal it contains; but on reaching the surface of the lungs, it gradually comes in contact with the air which we inspire at each breath, and the charcoal is actually *burned* away on the lungs, producing the same gas as that which causes the froth of beer—carbonic acid gas—which escapes by the mouth as we expire our breath. Thus we see that, in a chemist's point of view, we are actually *walking stoves.* Our food is our coals; our lungs the furnace or fire-place; our throat the chimney; and, if our young friends please, we will call the mouth our chimney-pot! It is thus explained *how we get heat from our food.* We may add, that after the blood has thus had its charcoal burned away on the lungs, it becomes of a beautiful red colour, as seen when it issues from a wound on our bodies.

The next property or use of food is that of affording us flesh, or muscle, and fat; and for this purpose we require other foods than those containing only starch or sugar, such as arrow-root, rice, sugar, &c.: this substance is called *nitrogen,* and is found in smelling-salts, all meat-food, and also in flour, milk, &c.

Let us take *flour*, as illustrating the *flesh-giving power* of food. If our young friends will put a handful of common flour into a coarse piece of linen, tie the neck so that none can escape, and hold the bag so that cold water from a tap may run through it, they will find that a quantity of milk-like fluid will run away. This is the starch separated from the flour, and is that portion of bread which affords heat to our bodies. When the water runs away quite clear, after squeezing the bag, open it, and inside will be found a sticky substance, which, from its somewhat resembling glue, has been called *gluten*. It is from this that we derive the flesh of our bodies, so far as bread is concerned; and in meat it is replaced by a substance exactly similar to the white of an egg; whilst pease, beans, and many articles of food, contain other substances having similar properties.

Lastly: if our young readers will dust some flour or bread-crumbs on a clean iron shovel, and hold this over a fire until it becomes red-hot, the charcoal, the starch, and the gluten will gradually burn away, and leave a white ash. This is *earthy matter*, and contains lime, phosphorus, silica, or pure flint, &c. It is from these that the bones of our body are produced. Meat, milk, pease, beans, &c., all contain the same earths, and thus supply what we may call *food for the bones of our bodies*.

We have thus endeavoured to explain how we get heat, flesh, and bones from our food. We may add, that after all, there is much more water than anything else in our bodies; and *all* our foods contain this liquid. Indeed, potatoes have about 70, turnips over 80, and cucumbers above 95 lbs. of water in every 100 lbs. weight of each; and three-fourths of our blood consist of pure water alone.

We now proceed to speak of the trades which are carried on to supply us with food. They include those of the Farmer, Miller, Baker, Butcher, Grocer, Fishing, &c.; and we shall also deal with Drinks, &c., in this chapter, and therefore include the Brewer, Distiller, Wine Maker, and many similar businesses or manufactures. The Dairy must also be noticed, for thence we get cheese and butter, which are so largely used with other articles of food.

THE FARMER.

The pursuit of farming is of the greatest antiquity, for we cannot obtain the fruits of the earth without labour: this was the condition imposed upon Adam and all his race, when he was driven out of the Garden of Paradise. It is the business of the farmer to plough and manure the land; to sow the seed, and reap and thresh it when ripe; also, to rear animals on that portion of his land unfit to grow corn. We may here name, that land fit or prepared to grow corn and other crops is called *arable;* whilst that kept for grass or hay, and to feed cattle on, is termed *pasturage.* The whole of the land of the farmer is thus divided into two kinds—namely, that for raising wheat, oats, rye, barley, potatoes, turnips, carrots, &c., as "crops," and that for producing grass, on which the cattle and sheep are fed, but which also supplies hay for their winter food.

The first step the farmer has to take is to prepare the land. After a crop has been removed, he ploughs the ground to the depth of a foot or more, for the purpose of bringing fresh earth or mould to the surface. All stones are removed, and if the land is wet, he drains it by digging long trenches, into which hollow pipes, made of earthenware, are placed. These are called drain pipes, and serve to gradually drain or draw off most of the water from the surface of the land. This is of the utmost importance, because if the soil were left too wet, the seed would rot and be unfruitful.

He must next supply proper food for the seed, for plants live by eating, just as we do; nay, more, they digest food, breathe, have sap or blood, and in many other respects are like animals. The "food" so supplied to the land is called "manures," and they consist of the waste of the stable, guano, bones, and numerous other substances which contain matter that the plant will afterwards require during its growth. We cannot here describe all these substances, but have already named many of their products when speaking of the nature of our own food, at page 95.

After the land is thus ploughed and prepared for the seed, sowing follows. Formerly it was done by hand, but now machines are used, which drill or make holes in the earth, and deposit the seed. The ground is then harrowed, by means of a square frame having iron spikes, and in most respects resembling the common rake, but, of course, much larger. By this the earth is turned over the seed, and so the latter is placed in a proper position for growth. As the air, moisture, and warmth act on it, growth takes place, and two processes or parts issue from it—one growing upwards, and forming the leaf and stem, and the other growing downwards, to form the root. Our young friends may easily study the mode of the growth of plants by half filling a clean glass bottle with water, and hanging, by means of a string supported by a card at the mouth of the bottle, a chestnut, which should be allowed just to touch the water. If the bottle be placed on a mantel-piece, in a moderately warm room, the seed will begin to grow, and throw out both a root and stem. Eventually leaves will be formed, and thus a forest tree may be made to grow—in a parlour. We have seen both acorns and chestnuts grown in this manner, and very pretty ornaments they make.

As the wheat, oats, &c., grow, and the stem is formed, the plants gradually increase in height, and at last the flower appears, which is followed by the seed. As the latter gets ripe, the stem of the plant gradually gains a yellow colour;

and on this, and the size, &c., of the seed, the farmer judges when he should reap or cut the corn. If he does this too soon, the "yield"—that is the quantity obtained—will be perhaps very small; and if he waits too long, the wind will shake the seed out of the ears, and so he will lose in this way also. The corn is cut by reapers, who hold a curved knife in the right hand, whilst they gather the cut plants by the left. The corn is then made up into heaps called sheaves, and if it cannot be threshed at once, is piled up in stacks, like hay stacks, until the farmer can find time for threshing.

Threshing consists simply in beating out the seeds from the ears of wheat, and it is performed by striking the stalks with an instrument called a "flail." This consists of two sticks joined together with a thong, one end being held in the hands of the labourer, whilst the other is made to beat the corn. This method is often substituted by the threshing-machine, driven by steam. In either case the husks that are mixed with the ears are driven away by means of a fan, which, by creating a blast of air, leaves the seeds quite clean. These are then packed in large bags, and are ready for the miller.

In this country corn is sown at two periods of the year—autumn and spring,—two different kinds of seed being employed, having names corresponding to those of the seasons at which they are sown. It will be unnecessary for us to describe the methods of sowing and reaping oats, rye, barley, &c., as all the operations nearly resemble such as are employed for wheat.

Turnips, carrots, potatoes, mangel-wurzel, &c., are chiefly used to provide food for cattle during the winter season, and form what are called "rotation crops"—that is, they are planted after corn crops have been removed from the soil, either in the same or following year. The object of this is to give the ground rest, or, more correctly, to allow the air and moisture to act on the earth, and yet to grow plants which do not rob the soil of lime, &c., as wheat crops do. By this the soil gradually recovers, or in other words, becomes again fit to grow corn.

Grass lands, or pasturage, are those which are not ploughed, but are kept solely for the growth of grass, to feed the cattle, sheep, and horses of the farm. The dairy depends on the grass-land, and according to its quality so is that of the milk, cream, cheese, and butter which can be produced by the farmer. In many parts of the South of England we may travel for scores of miles, and not see a ploughed field on either side of the road, all the land being devoted to the growth of grass for feeding the cows, and so producing milk. In Kent and Essex, on the contrary, a large proportion of the land is arable—that is, it is chiefly devoted to the growth of corn, and seeds of various kinds. A large part of Ireland is devoted to grass-land; and hence the immense quantity of butter which we get from the various parts of that emerald green island. Speaking of this, our young friends who have not visited Ireland can have no idea of the richness of its grass, which arises from the moist air, and warmer temperature than we have in England.

Hay is grass dried by the sun, and all our readers will be so familiar with the mode of hay-making that it will be needless for us to describe it. The grass is generally cut down, in the South of England, at the beginning of June, just before the seed is quite ripe; and if dry weather ensue, it soon becomes hay. If the hay, however, gets wetted by rain, and is stacked in this state, it heats; and we have often seen a large hay-stack completely burned down, owing to this singular property of some vegetable substances of producing what is called "spontaneous combustion." Cotton, flax, and some other substances, thus become heated by moisture and pressure, but more especially if oil has been dropped on them. And from this cause great fires often take place in warehouses filled with these articles. At first a slow burning goes on, just like that we described at a previous page (see page 94) as occurring with the charcoal of the blood on our lungs; but the heat rapidly increases until flame is produced. Cases have occurred in which human beings who have lived intemperate lives have thus "caught fire" within themselves, and have been burnt to a cinder—the cause being, as in the hay-stack, "spontaneous" or self-caused combustion.

We must now leave the farmyard, and visit the

Miller, Baker, Dairy-maid, and others who turn the products of the field into flour, cheese, butter, &c.

THE MILLER.

Under the head of "The Farmer" we have described the various operations by which seed is grown, so as to afford us wheat, &c., for making bread; but before corn is fit for human food it must be ground into flour, and this is performed by the miller.

When wheat, &c., is threshed, and packed in sacks, it is sent to the market, which is generally held at some large town in the district that is easy of access for the neighbouring farmers. Here the wheat passes into the hands of large buyers, who may be either millers or seedsmen, the latter buying the corn chiefly for the sake of selling it as seed during the ensuing year. The miller, on getting the wheat home, stores it in a granary or large warehouse, where it may be free from the attacks of vermin, as rats and mice, and kept dry until it is required to be ground into flour.

Corn-mills have been used from a very ancient date, and in olden times were always worked by hand. They are frequently mentioned in Scripture, and by heathen writers; and in many of the museums of this country, specimens of old corn-mills may be seen. In Egypt the mill now used has scarcely, if at all, varied in shape for the last four thousand years; and visitors to that interesting country may therefore see the grinding of corn into flour carried on in an exactly similar manner to that followed in the days of Joseph and his brethren.

The corn-mill always consists of two very hard stones placed one above the other, but separated by a short distance. The inner surface of each is cut with many lines or furrows, and in the centre of the upper one is a hole, through which the seed falls before it gets between the two stones. These vary in size from a foot to five feet in width, the former being used for hand, and the larger for steam, water, and wind-mills. The lower stone is generally fixed, whilst the other is caused to turn round at the rate of from 50 to 100 times per minute. Most of our young friends have seen at least the outside of a wind-mill, and know that it is by the action of the wind on the sails of the mill that the stones are turned. But the wind is so uncertain in this country that mills driven by it are getting fewer every year. Where a stream of water can be had, the miller uses it, employing some form of water-wheel for the purpose; and in the absence of a stream, the steam engine is adopted. Steam flour-mills, in fact, are now preferred to any other kind, and are very common in most of our large towns.

We must now return to the operation of grinding corn. The seed, dropped through a long trough or shoot, is admitted through the hole in the upper stone of the mill, by means of a hopper, which, worked by a rod, is constantly kept in a motion resembling that of tapping a sand-glass with the hand, the object being the same—namely, that of keeping the grains constantly passing through. Without this arrangement the hole might be stopped up, and so the supply of seed to the stones would of course cease.

When the seed reaches the open space between the two stones, it is instantly caught and rubbed by them. Its outer coat or *husk* is therefore broken, and the white particles come out. The whole gradually find their way to the outside of the stone, and fall into a kind of trough.

As the flour is thus produced, it is mixed with the husk; it therefore requires "dressing." This is done by a dressing-machine, which consists of troughs having sieves at the bottom, the meshes or openings of the sieves being of various degrees of fineness. The flour is thus separated into various sorts, the finest forming the best flour used in pastry, &c., whilst the husk, or coarsest part, is completely removed, and becomes the "bran" used for stuffing pin-cushions by our young lady-friends, but which is chiefly sold for feeding horses and cattle. Between the fine flour and bran there are various qualities, to each of which the miller gives a separate name; and each are packed up in bags, and are ready—at least the better sorts—for the use of the baker, whose trade we shall next speak of.

THE BAKER.

It is the business of the baker to prepare the flour received from the miller, so as to supply us with "bread"—an article which, in some form or another, is used as food throughout the known world. We must here state, however, that "bread" is made from very different materials in various countries. With us it is chiefly made from wheat, although occasionally rye is used. On the Continent, as, for example, in Germany, rye is as much used as wheat; whilst in Scotland the meal of oats is made into cakes, and is also largely consumed in the form of "porridge," or meal boiled in water with a little salt. Barley-meal was much used in England in former times to make bread, and of late years Indian corn or maize, which is much grown in Southern Europe and America, has been employed for making a species of cake or bread.

Before describing the manufacture of bread, we may mention that biscuits are produced by simply making a paste of flour, which being rolled thin, and stamped or cut out to the requisite shape, is then lightly baked. In many of our dockyards biscuits made for seamen are thus made by machinery; and of late years large manufactories have been constructed for biscuit-making by machinery, and they supply us with the cheap small kinds sold in the grocers' and bakers' shops.

Confectionery varies so much in its nature that we cannot describe its manufacture; besides, our young readers will often see it made at home, especially at Christmas time, when cakes, mince-pies, &c., are considered as "signs of the times."

We therefore shall confine ourselves to describing the common and new modes of making our "daily bread," as followed in this country.

The flour, when received from the miller's by the baker, is emptied into a large vessel called a "kneading-trough." It is then mixed with water and a little salt, so that it may be made into a soft spongy mass called "dough." Very frequently, potatoes, which have been previously boiled, are also added. The next step is to "ferment" the dough, which is done either by adding a little "yeast"—that is, the froth which collects on the top of newly-made beer—or by "leaven," which consists of sour dough. This substance, however, is rarely or never used, because it is apt to make the bread sour.

After the yeast, mixed with water, has been added to the flour, the whole is "kneaded" together by the hands of the baker till all the ingredients are completely mixed. The dough is then put to "rise," by which we mean that the yeast, acting on the flour, produces a gas—the carbonic acid—that makes little holes throughout the dough, and causes the cell-like appearance that we see on cutting a loaf of bread. This arises from the fermenting of the flour, and its object is to separate the gluten, of which we spoke at page 95, into small cells.

If bread were not thus fermented, or at least divided, it would be very indigestible; and this effect we find in eating paste that has been badly cooked; for, not being broken up as we have described, it proves injurious if partaken of in large quantities. We have known young people who have been made very ill through eating corn taken in gleaning fields, and simply mashing it up in milk. When thus eaten, it forms a sticky paste in the stomach, and may even produce death. We thus see how even the staff of life may, from want of proper preparation, become a deadly poison.

When the dough has properly risen, portions of it are cut off to make "loaves," which generally weigh about two pounds each. While the dough has been rising, the baker has been heating his oven. This consists of a large chamber of brickwork, and it is heated by a fire *inside it*, and not outside, as in our kitchen ovens. When the baker considers it sufficiently hot, he cleans it out, so as to remove all dirt and cinders, and then places each loaf on the floor of the oven separately, by means of a long rod having a flat end like a spade.

The door of the oven is now shut, and not opened again until the bread is completely baked. The loaves are then removed, and are ready for sale to the baker's customers. Generally the dough is baked by itself in a lump, but sometimes it is put into tins, the shape of which it assumes. Tin-loaves are generally sold under the name of "fancy bread," of which, however, there are many kinds, according as they are made with milk, arrow-root, &c.

Of late years many new methods have been employed to make bread by machinery. Dr. Dauglish's plan produces what is called "aërated bread," and does all the labour by machinery. He also uses no yeast, but forces a solution of carbonic acid gas, obtained from chalk, into the dough; and this, penetrating every part, swells it out, and answers just the same purpose as yeast, but prevents injury to, or the wasting of the flour. It is an excellent plan, makes light and wholesome bread, and is very cleanly, for the baker's hands never touch the dough in any part of the process whatever.

THE DAIRYMAN AND POULTERER.

These businesses are generally carried on together in most of our towns, and they are both more or less dependent on that of the farmer. Wherever cows are kept on a farm their milk is usually devoted to making butter and cheese; and the waste of seed and other matters also leads the farmer to keep *poultry*, as our domestic birds are usually called.

When the cows have been milked—a duty which requires much caution on the part of the dairymaid, for sometimes the animal will mischievously kick over the pail when it has just been filled, at other times will not be milked at all—the milk is put into shallow pans, in a cool place, and gradually the cream rises to the surface, as a thick yellow substance. It is carefully collected, and when required for butter is put into a churn. This consists of a long round vessel, in which the cream is kept constantly in motion by a rod to which arms are fixed. At length the greater portion of the cream becomes converted into butter, the remaining liquid forming what is called "buttermilk." If the butter is intended for immediate use, it is not salted, or only slightly so; but if it is to be kept for sale, salt is added in some quantity, to keep it from turning sour or rancid. When thus sold, it is called "salted butter."

We expect that most of our young readers are fond of butter; but very likely few of them have tasted it fresh from the dairy, when its flavour is very different from that which is sold in the shops. Sometimes, however, when the cow has eaten a piece of garlic leaf, the butter has anything but a pleasant taste, because that of the garlic, which resembles onions, has been thus given to it.

Cheese-making is another duty of the dairymaid. The milk in this case is curdled by a liquor prepared from "rennet," which is a portion of the stomach of the calf. On adding rennet to milk, "curds and whey" are formed, and it is from the curds that the cheese is made. They are removed from the whey, salted and pressed, being then moulded into the form which the cheese afterwards assumes. The latter, when made, is repeatedly turned, and in process of time, through various chemical changes, acquires a flavour according to the quality of milk which has been used. The yellow colour of cheese, and sometimes that of butter, is produced by using the pulp and seeds of the plant called *annotto.*

Cheshire, Gloucestershire, and many other parts of England, are noted for making cheese; whilst Dorsetshire, Devonshire, Cambridge, &c., are celebrated for the excellent butter they produce. *Clotted cream,* which is made by scalding fresh cream, is also largely afforded in Devonshire. Ireland also sends us much butter.

Poultry includes, generally speaking, all the birds used at our tables, such as fowls, ducks, geese, pheasants, partridges, grouse, wild-fowl, &c. These are all now natives of our country, and some are generally kept in the farmyard.

Lincolnshire is noted for its poultry, as are also Norfolk, Cambridge, Suffolk, Essex, &c. The fens or marshes in Lincolnshire produce an immense quantity of ducks, geese, and turkeys; and our supply for Christmas time is largely drawn from those parts. Pheasants, partridges, hares, rabbits, &c., are generally called "game;" and they all run wild in our woods or farm-lands, seeking their own food. But frequently they are "preserved;" that is, they are looked after by gamekeepers, to prevent them being wantonly destroyed; and in winter time their food is to some extent provided for them. Grouse, blackcocks, ptarmigans, and the capercailzie, are inhabitants of moors or rocky places; and are mostly found in the North of England, and in many parts of Scotland. Hares abound in all parts of the kingdom, as also do rabbits: a great number of the latter, however, are imported into this country from Ostend—whence the name of "Ostend rabbits." They are brought to that port from various parts of the surrounding country, which abounds with them.

Venison is obtained from the flesh of the deer, which, in a comparatively tame state, may be seen in many of our parks, as at Richmond and Bushey, near London. In the North of Scotland they run wild, in herds, and their pursuit gives rise to the sport called "deer-stalking."

Eggs of various birds are sold by the dairyman and poulterer, that of the hen being preferred. Although immense numbers are produced here, still we depend on France for our chief supply, and many millions are yearly sent to us from that country. Duck, goose, and turkey eggs are also sold in the shops; and as a greater delicacy, those of the plover, a small bird of about the size of a pigeon, may sometimes be seen.

THE GRAZIER AND BUTCHER.

The trade of the grazier consists partly in buying up "stock," as cattle, &c., are called; and also in fattening them for the market. He generally selects from those which he purchases, such as are most likely to produce a large quantity of meat, and the young cattle best answer for this purpose. Scotland sends annually an immense quantity of cattle and sheep to this country. They are hardy, but thin, having been poorly fed; but when they are put into our pasturage (see page 96), they quickly increase in flesh and fat, and, if grass be plentiful, yield a large profit to their owner. We get great numbers also from the Continent.

We cannot now tell whence our stock of sheep was first derived, but most probably from the South of Europe. There are many kinds of sheep, some of which are chiefly grown for their wool; whilst others are most valued for their flesh. It is equally difficult to tell whence our domestic ox had its origin. Oxen, like sheep, vary much in size, as, for instance, those from Herefordshire, and the Alderney cows. There are still some wild cattle kept in this country, as, for example, the Chillingham bull. The buffalo is a variety of the common ox.

The business of the butcher is that of killing and dressing animals for our food. We shall not go further into a description of his trade than by pointing out what he does with such portions of the animal as are not used for food. The hoofs afford glue; the fat is converted into tallow; the bones and horns into knife-handles and combs; the skin into leather; the hair of the ox is used in making mortar; whilst the wool of the sheep is spun up for making thread, &c. The butcher sells each of these articles to the manufacturer of the objects we have named; and, lastly, the blood is largely used for manures, and in some chemical manufactures. In some parts of this country it is made into "black puddings," when mixed with fat and groats. Thus, all parts of the animal are put to some use; indeed, the maxim "Waste not; want not," is followed in nearly every trade; and it will be well if our young friends always make it the rule of their conduct.

THE FISHERMAN AND FISHMONGER.

Almost every nation, more or less, depends on fish as an article of food; but with us the trades of catching and selling fish are of the greatest importance, living as we do surrounded by seas which abound with various kinds, as cod, mackerel, herrings, &c.; whilst our rivers supply us with the finest salmon, &c. Although it would doubtless be interesting to many of our young readers were we to enter into a description of the various fish, and the mode of catching them, that will be impossible, owing to the limited size of our volume: we must therefore be content to give a general account, and leave our young friends to peruse works on "Natural History," whence they may obtain the fullest information on the subject.

Fish are divided into two kinds—the sea-fish and fresh. The former are only, or chiefly, caught at sea, or about the mouths of rivers; whilst fresh-water fish inhabit rivers, lakes, and ponds. Our chief sea-fish are cod, hake, ling, gurnards, mullets, mackerel, haddocks, herrings, sprats, &c. Turbot, plaice or flat-fish, soles, &c., frequent the mouths of rivers; whilst salmon spend part of their time in the sea, but at certain periods frequent rivers, to which they proceed for the purpose of depositing their "spawn," as their eggs are called. Amongst our fresh fish are pike or jack, perch, tench, carp, roach, dace, gudgeons, whitebait, grayling, chub, barbel, trout, &c., the last being most esteemed of any of the kind. Lobsters and crabs are found in rocky seas, as are also oysters, cockles, mussels, limpets, periwinkles, &c. They attach themselves to the rocks, and there live. Shrimps and prawns like sandy or muddy shores.

The chief sea-fisheries of our country are the cod, haddock, mackerel, herring, pilchard, and sprat. The cod is a deep-sea fish, and, like haddocks, is caught by bait fixed on hooks, which are tied to long lines. When the line is fully baited, which is done as the fishermen are sailing from their port, it is thrown into the sea, and the fish, biting at the bait, are thus caught. The line is then hauled or drawn in, the fish taken from the hooks, and the boats proceed homewards to sell their load.

Mackerel, herrings, and sprats are caught by nets. They swim in great numbers called "shoals," and it is a pretty sight to watch the sea at times, when these shoals are passing. The water looks as if it were liquid silver, owing to the scales of the fish shining so brightly as they leap from the water. The nets are spread out for a great length across the course in which the fish are swimming, and the two ends being brought together, an immense number of fish are caught.

Cod, haddock, herrings, &c., are sold both fresh and salted. For the latter purpose the larger kind are cut open, cleaned, rubbed with salt, and dried either in the sun or in places where wood is kept burning; and it is the oil of the wood, by the burning of which they are dried, that gives the fish its peculiar taste. Herrings are salted and dried without being cut open; and an immense trade is done in them at Yarmouth in Norfolk, and in many parts of Scotland at the different sea-ports. We receive a large quantity of cod-fish from America, the "banks" or beds of sand beneath the sea, off the Island of Newfoundland, abounding with this fish.

Salmon, perhaps the finest of all fish, is caught both by net and hook; as is also salmon-trout. The time for fishing is when the salmon returns from the upper part of our rivers to the sea. About December, or sooner, they flock in immense numbers to the mouth of our rivers, and afterwards ascend them to deposit the spawn. It is a curious sight to watch them leaping over bars, weirs, &c. We have observed them in Scotland leap a height of several feet when any obstacle presents itself; and sometimes the numbers are so great that hardly time is given sufficient to count them as they spring, one after another, out of the water beneath to the river above. Strange to say, the salmon return annually to the same river. As soon as they have laid the spawn, which they hide underneath stones, in clear running water, they go back to the sea in great numbers in about January and the spring months. It is during this time that they are fit for food, and are most largely caught.

Fresh-water fish are caught also by net and hook, and many of our young readers know as much about the latter method as we can teach them. As we have already said, the fresh-water trout is the best of this kind, for they are all generally tasteless. Eels, however, are much esteemed, and abound in muddy banks, whence they are drawn by a baited hook and line, the bait being laid over-night. Jack or pike, if large, are very good, and somewhat resemble cod-fish. Whitebait, the favourite delicacy of Cockneys, is an exceedingly small fish, and is obtained chiefly in muddy fresh water, especially in the river Thames, whither it is supposed to travel for the purpose of spawning.

Lobsters are found on the rocky coasts of Scotland, and are also largely sent from Norway, where the coasts are also very rocky. They are caught in wooden boxes or traps, also in a kind of basket, into the ends of either of which they enter to seize the bait, but cannot get out again: eels are also frequently caught in this manner.

Oysters attach themselves to rocks, and so do mussels. The former are "cultivated"—that is, their beds are carefully attended to. They are obtained by "dredging," or tearing them from the rock by means of a "dredge." Those obtained off Whitstable, near the Thames, called "natives," are greatly esteemed. Large quantities are obtained round our coasts, especially about Scotland. Of late years the production of the oyster has been greatly followed; and our French neighbours have gone to great trouble in making "beds," and stocking them—a trade that has proved very profitable.

In this country much attention has also been paid to the artificial production of fish. The spawn is sought for at the places where the fish usually deposit it, and it is then placed in water running through troughs, until the fish are hatched. These are afterwards transferred to rivers, and left to their fate. By such methods we have been able to introduce salmon, and many other British fish, into Australia and our other colonies, that were previously unknown there.

It is the business of the fishmonger to purchase fish either from the boats or at markets in which they are exposed for sale. One of the chief of these is Billingsgate market, near London Bridge, and here fish are continually arriving, both by boats and rail. They are sold by auction, either separately, in lots, or in pads; sole and plaice being chiefly packed in the latter, which are baskets made of osiers or reeds. When the business of the market is at its height, the noise is deafening: we see men and women quarrelling as to whom the lot was knocked down to; others are hastening away with what they have purchased, without the least care as to who may be in their path; and a careless looker-on stands a good chance, if in their way, of carrying home with him on his dress, plenty of proofs, in the shape of fish-scales, &c., that he has visited the market.

THE MALTSTER.

Every nation has its peculiar "drink," and with us beer is certainly preferred to every other kind. It is astonishing what an immense quantity is drunk, despite all the efforts that have been made to lessen its use; and it is much to be regretted that there are too many who quite forget moderation, and indulge, to the ruin of themselves and families, in this and other intoxicating drinks.

Under the head of "Maltster" we have only to describe the methods by which barley is converted into malt; and we shall endeavour to explain this to our young friends, although chemistry is deeply involved in the process of "malting," as the business of the maltster is called.

The process entirely depends on the fact that starch, in a growing seed, is converted into sugar; and we have already pointed out at page 95 that wheat at all events contains starch, as is easily discovered in its flour. Barley, which is another kind of corn, similarly contains starch, and, in malting, this is converted into a kind of sugar, in the following manner:—

The seeds of barley are cast in heaps on to a large floor, and are moistened with water. They gradually become heated, owing to some chemical changes which they undergo, and eventually begin to grow or germinate. On this having taken place, the starch has been gradually changed into a sweet matter resembling sugar; and at this point the further growing of the seed is checked. The grain is immediately spread out so that it may cool; and eventually it is dried in a kiln—a species of oven—by which most of its moisture is driven away, and the malting process finished.

Malt, if thus dried at a moderate heat, preserves the same appearance, or nearly so, as that it had before being placed on the malting floor. It is, however, almost charred, or heated until it is of a brown colour, if intended for brewing porter, to which it imparts its dark colour. It is frequently crushed, so as to open the seed fully—a plan which much helps the brewer in his operations, to which our description of the next trade is devoted.

THE BREWER.

One of the greatest "sights of London" is its porter breweries, of which there are so many that, when they are all brewing together, they nearly pump dry all the deep wells of water under our great city. Some of them have many vessels for storing the beer, large enough to accommodate a table and a party of twelve or twenty persons to dinner inside of them: indeed, we have heard of a vat, used for a somewhat similar purpose, at a vinegar work, in which twenty-four persons could dine, without sitting too close to each other. There are many interesting objects besides these in our breweries. There are the large vats in which the "wort" is made; immense troughs in which it is cooled; the coppers in which it is boiled with hops; the cooperage where the casks are made in which it is sent out to the customers; self-acting machinery, by which these are made, and dirty barrels cleaned; so that, altogether, a brewery is a great sight for young and old.

Under the head "Maltster" we have just described how malt is obtained; we must now trace its progress until beer, ale, porter, &c., are produced from it.

The malt, if not bought ready crushed, is passed through machinery suitable for that purpose, on arriving at the brewery. It is then thrown into a large vat, in which, at the bottom, is what is called a "false bottom," which is pierced full of small holes. The object of this is to keep back the grains when the liquor is drawn from this vat, called the "mash-tub."

Hot water is poured on the malt, and after some hours it dissolves most of the sugar or sweet matter away.

The liquor thus produced is called "wort;" and it has a very sweet taste. It is drawn off from the grains by a pipe at the bottom of the vat, and conveyed to large coppers, where it is boiled with hops —the leaves of the flower of a plant largely grown in different parts of Kent for the use of the brewer. The hops impart a bitter flavour, and also tend to "keep" the beer; that is, they prevent its changing to a sour state. As soon as the wort has been sufficiently boiled, it is pumped up into large shallow vessels called "coolers," which cool it as quickly as possible.

Yeast is then added to the wort, when fermentation takes place, by which a gas we have already mentioned, when describing the fermentation of bread—carbonic acid—is produced, and a portion of the liquor is converted into spirit, having the intoxicating power that gin, brandy, &c., possess. After a certain time the fermentation is stopped, and beer is at last produced. It is then run off into large vats, from which casks of various sizes are filled, according to the wants of the brewer's customers.

This is a general account of the method by which beer is produced; but we must explain the difference between each kind. If white malt be used, the process we have just described would produce *sweet or mild ale;* or, if much hops were boiled with the wort, then *bitter* or *Indian pale ale* would be afforded. *Old ale* is mild ale kept for a long time, until all the sweetness is lost, and a harsh, or almost sour flavour is produced. *Porter* results from using burnt malt; and *stout* is porter of a much stronger brewing. There are many kinds of ale, varying in strength. The commonest, often called "four-penny" ale, is produced by adding more water to the grains from which the stronger kinds have been made, and then brewing it. The grains, when of no further use—that is, when all their sweet matter has been extracted or removed—are sold to the cow-keeper for the use of his cows.

We have as yet only mentioned London as noted for its breweries, but at other places large quantities of ales, &c., are produced. Burton-on-Trent is specially noted for the great breweries of Messrs. Bass, Messrs. Allsop, and others, where great quantities of *pale ale* are brewed. There are also other parts of the kingdom noted for ales, as Kennet, Nottingham, Margate, &c.

In Scotland there are also large breweries, especially in the neighbourhood of Edinburgh, where ale is largely produced—most being of the sweet kind, known as *Scotch ale.* The pale ale for export to India is also brewed there in considerable quantities.

THE DISTILLER.

So far as malt-spirits are concerned, the early operations of the distiller much resemble those of

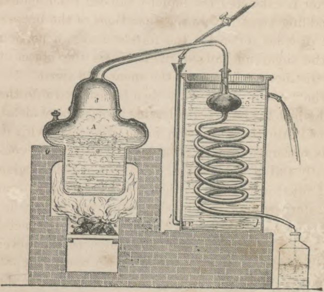


PLATE 8.—THE STILL, p. 123.

the brewer: he, however, generally mixes with the malt a portion of grain that has not been malted. Wort is formed in the same manner as that already described; and when the whole of the sweet matter is extracted, the liquor produced is fermented by adding yeast. Here the operations of the brewer and distiller differ, for the former leaves a portion of the sugar unchanged; whilst it is the object of the distiller to change *all* the sugar into spirit.

The "wash" or liquor is then transferred into the still, which is a large boiler having a long pipe of metal, turned into the form of a worm, connected with it. This worm is held in a separate vessel, kept constantly full of cold water. The still or boiler being half filled with wash, is then heated by a fire; and the spirit which the liquor contains rises in vapour; but coming in contact with the sides of the metal worm, it is condensed, and falls down to the lower part, running out into a vessel placed to catch it.

Our young friends may easily understand the nature of a still, by fastening a piece of tin or other metal tubing to the spout of a tea kettle, and surrounding the tube with a cloth wetted with cold water. If the water in the kettle be boiled, the steam, as it passes through the metal tube, will be condensed, and will trickle out as water. Precisely the same operation, only on a larger scale, is carried out by the distiller.

The spirits thus produced are, however, unfit to drink, and require rectifying. This is a separate branch of business, and is carried on by the "rectifier." He buys the raw spirits produced by the process we have described, and re-distils them, adding various flavours. Thus, with juniper berries gin is produced; whilst whisky is the spirit unchanged, and only flavoured by the malt from which it is produced.

Rum is obtained by distilling the molasses or treacle obtained from sugar; and it is chiefly made on the estates where the sugar cane is grown, especially in Jamaica. Brandy is obtained by distilling the spirit obtained from wine, coloured by the addition of burnt sugar; *liqueurs* are spirits flavoured with various essential oils, as the almond, &c.

THE WINE GROWER OR MAKER.

Wine, as all our young friends know, is produced from the grape, and the trade of making and selling it is one of the most important in all parts of the civilized world.

Wines generally obtain their name from the country in which they are made, and the place where the grapes that produce them grow. Thus we have Spanish, French, Hungarian, &c., indicating that such are obtained from Spain, France, and Hungary. These wines differ greatly from such as are made in our own country and sold as "British wines," which, indeed, do not deserve the name of "wine," as we shall see when we describe the production of each kind. Spain and Portugal supply us with Sherry and Port; whilst Moselle, Champagne, Chablis, Claret, &c., are sent to us from France.

The grapes are grown in vineyards, and the vines are raised on poles, presenting a beautiful appearance, and somewhat resembling the hop-gardens seen about Maidstone and many parts of Kent. When the fruit is gathered, it is put into a press, and the juice is thus forced out and conveyed to large vats. Here it is allowed to ferment, and it requires no yeast to cause this, as we have shown to be needed in the case of malt liquors (see page 121); for the grape contains a principle that answers the same purpose, which speedily turns the sugar it contains into spirit. When this is completed, the wine is cleared, and stored away in casks for export to foreign countries. Some wines retain a portion of the gas produced during fermentation (see page 121), and after being bottled, give it out when uncorked, as is seen in Champagne. Such are called "sparkling wines;" whilst Port, Sherry, &c., are termed "still wines," because they give out no gas under such circumstances.

If the black or red grape be used, dark-coloured wine is produced, of which Port is an example; when the white grape is employed, the wine is of a light colour, just as we notice in Sherry. The "crust" of Port wine is produced by the tartar—the same as cream of tartar used in medicine—settling down on the side of the cask or bottle, its colour being caused by that of the grape having united with it.

If wine be put into a still (see page 123), and distilled, it affords a spirit which, after flavouring, becomes "brandy." "Pale brandy" is the spirit as obtained from the still; whilst the "brown" kinds are made by colouring the spirit with burnt sugar.

One of the great sights in London, and also in the countries where wine is made, is found in the cellars where the casks are stored. At the docks near London, acres of ground are thus covered, and the long rows of casks completely bewilder the visitor who sees them for the first time.

"British wines" are made by boiling the juice of our fruits with sugar, and adding brandy or other spirit to give them strength. Currants, gooseberries, and many other fruits, thus afford a pleasant drink. Sometimes foreign fruits, &c., are similarly treated, and ginger, raisin, orange, and other "wines" are produced.

THE VINEGAR-MAKER AND PICKLE MANUFACTURER.

These two trades, although generally, if not always, carried on separately, are yet to a large extent one in their object—namely, that of preserving fruit, &c., by means of vinegar; and we have therefore put them under one head.

Vinegar may be produced in various ways. Thus, when we burn a piece of wood, the smoke irritates the eyes and nose, which is owing to the production of a kind of vinegar called by the chemist "pyroligneous acid," or wood-burning acid—that means the same thing. The liquid thus obtained, however, is very impure, and therefore not fit for use at our tables or for pickling. The chief source of vinegar is ale or beer in this country, although in France white wine, which has turned sour, is used—the principle in either case being, that spirituous matter, if acted on by the air, soon produces acetic acid, which is the cause of the sour taste, and is also the chief ingredient or basis of all vinegars.

The vinegar-maker either brews his own beer, nearly after the manner described at page 120, or buys sour ale from the brewer. He then exposes it to the open air for some weeks, until all the spirit is turned into acetic acid, or he causes it to flow over birch twigs placed in a large vat. By dashing over these, the ale is so constantly exposed to the action of the air as to speedily become changed; and as the liquid falls to the bottom of the vat, it is pumped up again, and allowed thus constantly to flow over the twigs, until the process is completed. The vinegar thus formed is allowed to settle, and is cleared, when it is ready for table use or for pickling purposes.

Of late years the *vinegar plant* has been used in our families. It is a kind of fungus or mushroom, and when placed in a mixture of sugar, treacle, and water, soon converts the liquid into vinegar. It acts similarly to what yeast does, only it produces acid instead of spirit. The process of making vinegar depends on what is called "acetous fermentation," whilst that of producing spirit is called "vinous fermentation."

Pickles are made by first salting the fruit, as onions, cucumbers, &c., cut into slices; these are then boiled in vinegar with spices, and after bottling are ready for use.

THE SUGAR BAKER OR REFINER.

There are various sources of sugar in nature: in fact, a large number of plants contain it; but those to which we are chiefly indebted are the sugar-cane beet-root, maple, and palm. The first is the best source; the second, that largely used on the continent of Europe; whilst maple sugar is produced by the Canadian colonists; and the palm is a source of sugar to the African and East Indian native. We shall confine our remarks to cane-sugar, as it is that kind which is exclusively used in this country.

The cane is largely cultivated in most tropical countries, especially in the West Indian Islands. It belongs to the grass family, and grows to a height of from fifteen to twenty feet. On being cut down, the canes or stems are passed through a mill consisting of iron rollers, and by these the juice is completely extracted. This liquid is then boiled with lime water, and after being allowed to settle, the clear portion is drawn off and evaporated till crystals form. In this state it is mixed with a large quantity of molasses or treacle, which is removed by allowing the sugar to drain in suitable vessels; it then forms the brown sugar sold in the shops. The molasses is used to produce rum, on being distilled, as we have already named when speaking of the distiller.

It is the business of the sugar refiner or baker to remove all the colour still left in sugar thus prepared; and this trade is largely carried on in England and Scotland—London, Glasgow, and Greenock being the chief seats of sugar refining.

The brown sugar, as imported, is dissolved in water, to which lime water has been added; and as soon as the impurities have settled, the liquid is filtered through flannel. To remove the colour, it is afterwards filtered through beds of animal charcoal, which is obtained by burning bones. The clear syrup is then conveyed to a vessel called a "vacuum pan," where, by the aid of steam externally applied, it can be boiled at a low temperature, owing to the air being removed from the inside of the vessel. Crystals of sugar are gradually formed, and the mass is then ladled out of the pan into vessels of a cone-like shape, and thus the "loaves" of sugar are formed.

When these are filled, a solution of pure white sugar is allowed to trickle through the sugar crystals in the vessel. By this all the colour is completely removed, and what runs away forms the "treacle" sold in our shops.

The loaves are then permitted to dry gradually, and when quite solid are removed from the cones. The pointed end is turned on a lathe, and the outside of the loaf trimmed. Each loaf is then covered with paper, and taken into a room heated highly; and thus the process is completed.

Sugar has a great number of uses besides that of sweetening our tea, &c. It is much employed in preserving fruits, which it does by so covering them as to prevent the access of air; lozenges, confectionery, &c., consume much; and it is also used in brewing, distilling, &c. Strange to say, that deadly poison, oxalic acid, can be produced from sugar by boiling it in nitric acid or aquafortis. This is one of the many astonishing changes which the science of chemistry unfolds to us.

THE TOBACCO MANUFACTURER.

Amongst all the habits universal throughout our race, that of smoking seems one of the most common. Nearly every nation smokes some substance, which has a quieting, or, as it is more scientifically called, a narcotic effect. In China opium is enormously used; in India a species of hemp; but tobacco, after all, is the article most generally employed, especially in Europe. We shall therefore give an account of its growth and manufacture into cigars, "tobacco," and snuff.

The chief tobacco-growing countries are Virginia, in the United States; Cuba, in the West Indies, where most of the islands also produce it; some parts of the continent of Europe, Asia Minor, &c. The plant grows to a height of about six feet, and bears oblong leaves of from ten to twenty inches in length, and about five inches in their greatest breadth. When the leaves are ripe, the plant is cut down, and each stem is hung up in barns to "cure." A kind of fermentation takes place, which brings out the narcotic properties of the tobacco. The leaves are afterwards dried, and packed in casks for exportation to Europe and other countries.

If the tobacco be intended for smoking in pipes, the manufacturer puts the leaves, after they have been opened out and wetted, into a machine, in which, by means of a large knife worked by a steam engine, it is cut into thin shreds. The light-coloured tobacco is thus converted into what is sold as "returns;" whilst the darker and stronger sort affords "shag;" "bird's-eye" is that in which small portions of the stem have also been cut up, and which give the appearance that has suggested the name. Other kinds of tobacco are also thus made, which are often named after the countries from which they are imported.

Cigars are formed by rolling a portion of a sound leaf round pieces of other leaves, forming the inside or "gut" of the cigar. Cigars, when made at the place where the tobacco has been grown, are called "foreign;" whilst "British cigars" are those which are made here from the tobacco imported from foreign countries; for tobacco is not allowed to be grown in this country except as a botanical specimen. This is owing to the large revenue which the nation collects on tobacco, as received from abroad, and which would be entirely lost if the plant were permitted to be cultivated here.

"Pig-tail tobacco," used for chewing, is made by twisting together leaves of tobacco by means of a kind of spinning wheel. A dark kind of leaf is generally chosen for this purpose, and the colour is heightened by moistening it with tobacco water.

Snuff is produced by grinding the stalk and leaf, either separately or together, the darker kinds being moistened, whilst the light sorts are sold dry. High-dried snuffs are obtained by grinding stalks or leaves which have been previously heated to a high temperature. Fancy snuffs are produced by scenting the above with oils of various kinds, as bergamot, rose, &c.

Tobacco pipes are made by shaping clay of a fine kind into the requisite form: they are then exposed to a great heat, to make them just like earthenware. Meerschaum pipes are made of a soft earth, used also by the natives of Turkey (whence it is obtained) as a soap. Other kinds are made from the roots of trees, glass, and a great variety of materials. "Hookahs" are pipes so arranged that the smoke, before it reaches the mouth, shall pass through clean water, or waters perfumed with various oils; and this is a method commonly followed by Eastern nations.

And now a word or two with our young friends about the use and abuse of tobacco. It is one of the most seductive and harmful habits which a young person can acquire. On first smoking a pipe or cigar, every person experiences the most painful feelings —resembled precisely, but only, by violent sea-sickness. This feeling gradually goes off; but each "pipe" or cigar produces a thirst which often, nay, generally, leads to another bad habit—drinking. A young person, if an habitual smoker, has the effects of smoking speedily shown. He loses his appetite, stunts his growth, gets a yellow-looking skin, wastes his pocket-money, and, on the other hand, does not get an iota of advantage from the habit.

From what we have said, our young friends may imagine that *we* have neither "smoked" nor "snuffed." They are wrong; for we have done both for many years, and only use our own experience to warn others never to smoke a pipe or cigar, or take a pinch of snuff, even "for the fun of it." Bad habits are easily learned, but with difficulty got rid of: they at first cling to us with the gentle touch of the child, but at last hold us with the iron grasp of a giant. A French proverb says, "It is the first step that costs;" therefore, let our young friends never begin, so that they may never have the painful task of breaking off, these bad habits.

There are many other trades engaged in supplying us with articles of food, drink, &c., to which we only allude in general terms, because they involve no special process of manufacture, or other detail requiring separate description.

The *Grocer* provides us with tea, coffee, sugar (of which we have already described the mode of refining), spices, &c. Tea, as all our young friends know, is chiefly produced in China, and is the leaf of a small shrub. The leaves, after being collected, are dried on a metal plate heated by a charcoal fire. They are afterwards sorted and packed in chests to be sent to this and other countries. Coffee is the seed found in the fruit of a plant growing in the East and West Indies, &c. This fruit resembles a cherry, and the seeds, on being removed, are dried. They require roasting before coffee can afford its peculiar flavour. Cocoa is also the seed of a plant properly called *cacao*, which has no resemblance whatever to the cocoa-nut that we use as a fruit. Spices are the seeds or fruits of plants grown chiefly in hot climates; as are also the different kinds of peppers, with the exception of Cayenne, which is made by pounding the pod of the capsicum.

The *Market Gardener* and *Greengrocer* produce and sell the fruit and vegetables which form a portion of our food. Fruit in many foreign countries is an essential article, being, in fact, the "daily bread" of the lower classes. Besides fruit grown in this country, we import immense quantities from various parts of the world.

CHAPTER III.

TRADES CONNECTED WITH METALS.

WHILST describing the trades connected with the supply of our clothing and food, we found ourselves largely indebted to the animal and vegetable kingdoms. We have now, however, to describe those trades which depend entirely on the solid matter of our globe, called in science its minerals or metals. They are extremely various in their qualities, of great utility, and, like most other objects which are worth having, cost great trouble and expense in procuring and preparing them for the purposes of man.

Metals are very rarely found in a pure state; in fact, as a rule, only two are thus found: they are platina and gold. All the rest are obtained from what are called their "ores," in which state the metal is united with other minerals. Thus, the shining yellow substance we often see in coal is an ore of iron; for it consists of that metal united with sulphur or brimstone. Vermilion, again, is an ore, for it contains mercury—the metal used to "silver" looking-glasses and to fill barometers, &c.

Ores are generally obtained from mines, which are deep pits dug into the earth, or into the sides of hills. When the *miner* thus digs or burrows into the earth, he hopes to meet with a "lode" or "vein" of the ore, as the mass of that substance is called. On reaching that, it is hewn out, and raised by means of baskets to the surface of the earth. For this purpose long flat ropes are used, which are worked by a steam engine at the top of the mine; the engine also works pumps, by which the water is raised out of the mine; and it lets down and conveys upwards the miners and horses that work below.

Perhaps few, if any, of our young readers have been down in a mine: we shall therefore describe visits that we have made. Before descending, we have to put on a thick coat, to keep off either the wet or dust, and frequently both. We next get into the skip or basket, and are rapidly let down—gradually losing all daylight, except that which dimly descends from the top of the "shaft" or pit we descend by; and this is not more than six or eight feet square. Perhaps we have descended 600 feet, and at last reach the bottom; but many mines are far deeper. Looking right and left, we see men working with pickaxes and shovels, breaking out the ore or coal, and throwing it into trucks, which boys or horses drive to the bottom of the shaft, where they are hooked to the ropes, and raised to the top.

In going into an adit—that is, a passage driven straight into the side of a hill—each visitor is supplied with a small candle. There is barely width

PLATE 9.—EXTERIOR OF AN IRON FURNACE, p. 137.

enough for a person to walk; and the passage is so low that it is necessary to bend down nearly on "all fours." We once went into a lead mine of this kind in the north of Yorkshire, accompanied with several ladies, and fine fun we had, for on returning to daylight every one was completely covered with a soft brown mud, which had trickled through on our dresses. This is one of the discomforts of the miner; and the heat, with the danger of masses of earth falling, explosions of gases, and other such matters, shorten the lives of the men, and often destroy hundreds in one moment.

When the ore of ordinary metals—as of copper, iron, lead, &c.—is brought to the top of the mine, it requires "roasting," to drive away the sulphur, &c. This is done by mixing it with small coal, in heaps, and setting fire to them. After awhile the sulphur is driven off, and the ore is then fit for smelting. We cannot afford space to describe the different methods of obtaining each metal from its ore, and shall therefore select one—iron—as being the most interesting, and because the metal, when obtained, is the most useful of any that the earth affords us.

The ore of iron having been "roasted," is allowed to cool, and is then conveyed to an immense furnace, perhaps 40 feet high and 8 or 10 feet wide. The ore is thrown in at the top, mixed with coal or coke and lime; the latter being intended to act as a "flux," or substance which will unite and dissolve away the impurities with which the metal is mixed. The heat of this furnace is kept up by means of "blowers," which are air-pumps, driven by a powerful steam engine, and acting in precisely the same way as the bellows used in our kitchens. After a time the metal is completely melted down, or "reduced," and twice a day the furnace is "tapped"—that is, the iron is allowed to run out through a hole in the bottom. The metal, which is brilliantly hot, and throws off myriads of sparks, runs into a long channel called a "sow," and branches off into shorter ones on either side, called "pigs." In this condition it is called "pig iron," and when cold, forms bars about three feet long and two inches thick. Our young friends will readily understand how metals are thus got from their ores, or reduced, by trying the following experiment:—Mix a little red-lead—which is an ore of lead—with some powdered charcoal, and make it into a paste with a little oil. Put the paste into the bowl of a tobacco-pipe, and place the bowl in a strong fire. After a time, the black paste will entirely disappear, and if what is left be poured into a pail of cold water, the metal—lead—will be found at the bottom as a shining lump. It is by precisely similar means, only on a larger scale, that nearly every metal, but gold, platina, and silver, is obtained from its ore.

Gold is generally found in grains, or lumps called nuggets, and our chief sources of that metal are Australia, California, and British Columbia. Silver is found in Mexico, Peru, &c.; but it is also largely

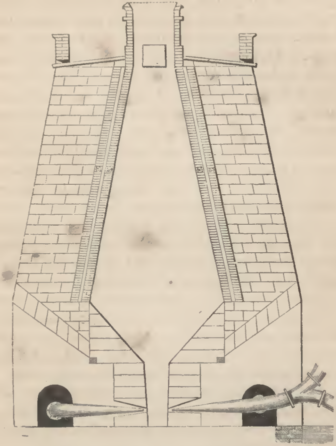


PLATE 10.—INTERIOR OF AN IRON FURNACE, p. 138.

obtained in our own country, mixed with lead. Mercury, which comes from Spain; while copper, lead, iron, and zinc are found in a few counties in England and Scotland. Tin is obtained from Cornwall, and also from the East India Islands; silver, also, especially from America, in large quantities of antimony, and [illegible] &c. The other less used metals are obtained from various parts of the globe, which we cannot [illegible].

The qualities of metals vary, and hence the different purposes to which they are applied. Gold, silver, platina, copper, iron, &c., are very ductile, and may be rolled into sheets, and beaten out by hammering into thin leaves. They therefore are employed in many of the trades which we shall describe, and form the goods called "hardware," "ironmongery," and "cutlery." Many are brittle, as is the case with zinc if pure,—a process which renders most of the metals [illegible] their becoming liquid [illegible] They can [illegible] into moulds [illegible] by [illegible] two or more pieces when [illegible]. These metals are [illegible] and [illegible] [illegible] "bronze," "bell-metal," &c.

We must now, however, [illegible] mention the various trades depending principally [illegible], and to give a further description of each as we find out their separate uses. Many metals are put into useful forms by rolling them between very [illegible] obtained in our own country, mixed with lead. Mercury chiefly comes from Spain; whilst copper, lead, iron, and zinc are more or less common in England and Scotland. Tin is obtained from Cornwall, and also from the East India Islands, which also, especially Borneo, send us large quantities of antimony, used in printers' types, &c. The other less used metals are obtained from various sources and places, which we cannot spare time to name.

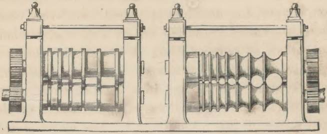
The qualities of metals vary, and hence the different purposes to which they are applied. Gold, silver, platina, copper, iron, &c., are readily drawn out into wire, rolled into sheets, and beaten out by hammers into thin leaves. They, therefore, are employed in many of the trades which we shall presently describe, and have the properties called "ductility," "tenacity," and "malleability." Many are brittle, as is cast iron before it is puddled—a process which removes most of its impurities: it then becomes ductile, &c. Only two metals can be welded—that is, united together by hammering two or more pieces when red-hot. These metals are platina and iron. Most metals are fusible—that is, they can be melted and cast; hence the trade of the "Founder," who "casts" bells, guns, &c.

We must now, however, proceed to mention the various trades depending on metals, and reserve a further description of each until we find out their separate uses. Many metals are put into useful forms by rolling them between heavy rollers, so as to increase their length. Rods, bars, and sheets of iron, copper, &c., are thus produced; and this operation is generally carried on at the works where the metal is reduced; but it sometimes forms a separate branch of business. Railway rails are manufactured by causing iron, heated to a white heat, to pass through rollers having grooves of the exact shape of the intended rail. But many metals are rendered of the requisite form by first melting them and then casting them in a mould. We shall commence by describing this process: it gives rise to the trade of

THE FOUNDER.

The metals chiefly used by the founder are iron, brass, gun and bell metal, copper, lead, tin, and zinc. Brass is a mixture of copper and zinc; and we may here name that such mixtures are called "alloys." Bronze and gun metal consist of an alloy of about nine parts of copper to one of tin, whilst bell metal contains four or five parts of copper to one of tin; pewter is a mixture of lead and tin; and type metal is composed of lead and antimony.

The first business of the founder is to produce a mould, in which the metal is to be cast, no matter what the object may be; the latter being produced by running the metal in a melted state into the mould. It would take too much space to describe the method of casting all the articles which fall



Front View of the Rollers, p. 140.

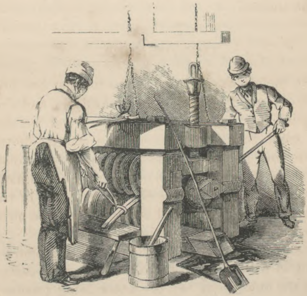


Plate 11.—Machinery for Rolling Iron, p. 140.

into the hands of the founder; we shall therefore select one as illustrating the general method, and afterwards mention any particulars by which other processes vary from that we are about to describe.

Supposing, for example, we required an iron wheel, with teeth round its rim, to be cast: a pattern is first made in wood, being exactly like the intended wheel in every respect, except that of the material used. This pattern is then blackleaded, so that it may be readily lifted out of the mould, without breaking any portion of the latter away as it is removed. The founder has iron boxes called flasks, and taking one of these, a little larger than the wooden wheel, he places it on the floor of the foundry. This is always made of sand, so that it may be easily made level, and also form channels through which large quantities of melted metal can be run from the furnace in case large castings are to be made.

The trough or flask being placed flat on the floor, is partly filled with a mixture of sand, loam, &c., and the pattern wheel is forced into it, to the extent of *one-half* of its depth. The sand immediately takes the impression of this half of the wheel, and all parts not touched by it are made perfectly smooth and flat; they are also dusted over with burnt sand, so that the other half of the mould may not stick to the lower half when the two are afterwards separated to remove the wooden pattern, before casting the metal wheel.

The other half of the mould is formed by placing an empty flask or frame over the one now holding the wheel, and the half mould already made. Sand, &c., is then thrown in, and beaten down until the wooden wheel is completely hidden. The two flasks are then separated, when the upper one will be found to have received an exact copy of the top half of the wooden pattern. This is removed, and the two halves of the mould are then replaced exactly as they were before, with the exception that the pattern has been taken away. By doing this, the founder has left an exact *hollow* copy of the solid wooden pattern. Holes are made through the solid part of the mould, through which the melted metal can afterwards be poured, and the steam which is thereby produced be allowed to escape.

Whilst the mould has thus been formed, other men have been melting the metal. This, in the case of iron, is done in a furnace about ten feet high. The fuel is generally coke; and this is cast in at intervals, together with lumps of old and pig iron (see page 138). A fan, driven by a steam engine, and acting like a powerful pair of bellows, supplies air to the furnace, and produces so great a degree of heat as soon to melt the iron.

When all is ready, a stopper is removed, and the melted iron flows in channels on the floor, in the case of large castings, to the mould. But small moulds, such as we have been speaking of, are filled by crucibles, or other vessels, full of the melted metal, which is poured into the holes left at the outside, as we have just described. The metal soon runs into every part of the mould, which is then allowed to cool. On being opened, an exact copy of the wooden pattern is seen, and a cast-iron wheel is of course produced. It is then chipped, filed, cleaned, &c., and is ready for any purpose for which it is intended.

Such is an outline of the method by which wheels, beams, fire-grate bars, and a large number of solid objects are cast; but a very different plan in respect to the moulding is pursued when hollow articles are required; as, for example, bells, cylinders of steam engines, pipes, &c. In such cases an inner and outer mould must be used, the inner one being called a "core." Thus, the core of a cannon, bell, or cylinder, is a solid mould, the *outer* surface of which corresponds to the inner surface of the article; whilst the outside of the article would be formed against the *inner surface* of the *outside* mould; and thus the metal, when melted, is poured or allowed to run into the space *between* these moulds, and the bell, cannon, &c., are formed.

Castings, or metal copies of objects, are made of all sizes, by methods like those we have described, from iron, when intended for wheels, beams, girders, cylinders, presses, &c.; from gun metal, when used for cannons and many kinds of machine-bearings; from bronze, if for statues; from brass, as in the wheels of clocks and small ornamental objects;

and from bell metal, when employed to cast bells. Amongst the latter, we may mention the great bell of Moscow, which is 21 feet high, 22½ feet wide, 3 inches thick, and weighs about 400,000 pounds, or nearly 180 tons. It is not used as a bell, but has been consecrated as a chapel. There is a large bell, also, at Rouen, in France, weighing 36,000 pounds. Old Tom of Lincoln, an English bell, weighed 9,894 pounds; and we have now in use many bells of great size, as, for instance, that at St. Paul's Cathedral, and "Big Ben," at the Houses of Parliament, in London.

THE BOILER-MAKER.

Amongst the heaviest kinds of metal manufacture is that of boiler-making; and a few remarks descriptive of the operation will also serve to explain the methods of making water-tanks, wrought-iron girders for railway and other bridges, copper vessels for sugar refiners, and all other articles in which plates of metal are rivetted together for large works.

In all cases the metal is used in the form of sheets, great care being taken to choose the best kinds—that is, those which have the greatest tenacity in regard to their weight or thickness. It is also essential that the metal should be quite free from flaws or unsound parts, because the greatest strength of a boiler will not exceed that of the *weakest* plate used in it. The plates are generally used in a flat state, but in round-ended or circular boilers they are heated, and beaten strongly until they acquire the proper shape. For iron vessels the wrought metal only is used, although steel has of late years been partly employed, both for building vessels and in making boilers. Copper being a more tenacious metal than iron, may be used safely in the cast state, but its expense causes it to be but rarely employed for the purposes we have named.

The metal requires to have its edges drilled with holes; and this is done by placing the plate in a machine, by which a punch is driven right through the plate, and a piece of metal forced out. The holes thus made are intended to receive the rivets or iron pins by which two or more plates are to be joined together. This is done by laying the plates over each other, so that the holes in each shall correspond; and the rivet, having been first made red-hot, is inserted and hammered stoutly on one side, whilst the smith forces it against the plate with a piece of metal on the other. Rivets are pieces of iron rod, of about two inches long, and furnished with a collar or shoulder resembling that forming the head of a nail; in fact, they are very thick, short, but heavy nails. As the iron of the rivet cools, it powerfully contracts, and thus the two plates are brought together with enormous force; and, indeed, so much so, as to make the joints completely water-tight.

The tops and sides of boilers, however, cannot be joined in this manner, and for this purpose a piece of "angle iron" is used. It is nearly of the shape of the letter L, and the plates are rivetted to each of its sides, holes having been first punched in them, to correspond with those in the plates. This plan saves the necessity of bending the plates, which tends to weaken them, and also enables the boiler-maker to form any shaped vessel with comparatively little trouble. Sometimes the plates require to be cut, and this is done by a machine, driven by a steam engine, as effectively as a boy might cut a piece of paper with a knife. Planing machines, also driven by steam, are used to reduce the sides of the plates before joining them together, and for other similar purposes.

Iron ships are built on precisely the same plan as that we have described; but we shall have to speak more fully of them at a future page.

The immense railway bridges crossing our roads, rivers, &c., are made in a similar manner. The largest of the kind that we have in this country is the Britannia Tubular Bridge, in Wales, which carries the Holyhead Railway across the Menai Straits, and is entirely made of plates joined in the way we have described. It consists of two lines of tubes, each 1,513 feet long, and placed side by side. The plates are from $\frac{3}{8}$ths to $\frac{3}{4}$ths of an inch thick; the height of each tube is 26 feet in the centre, and $18\frac{3}{4}$ feet at the ends; and the width is 14 feet. The weight of the whole, including the railroad metal, is 10,540 tons. There is a larger bridge of the same kind near Montreal, in Canada, for it is nearly two miles long. Both bridges were constructed by the celebrated engineer, the late Robert Stephenson.

THE WIRE-DRAWER.

Platina, gold, silver, copper, iron, steel, brass, &c., may be easily drawn out into a wire; and this operation forms the business of the wire-drawer. His implements are very simple, and his art depends on the tenacity of metals, or that quality by which their parts or masses are kept together. Some metals possess but little tenacity, as is seen in lead, zinc, and tin, which, although occasionally drawn into wire, have but very limited use in that form.

The wire-drawer uses a "draw-plate" and a "draw-bench." The former consists of a plate of very hard steel, drilled with holes of various sizes; and it is by drawing the metal through these holes that it is converted into wire. The draw-bench is an arrangement in which, by means of a vice or pincers, that catch hold of the metal, and long arms moving rollers, the wire is drawn through the draw-plate.

The wire-drawer commences by softening the metal as much as possible; and this he does by heating it red-hot, and allowing it to cool gradually. The end of the bar is then filed down until it is small enough to go through the largest hole in the draw-plate, and to reach quite through it. He then fastens the vice or pincers of the draw-bench on to this projecting piece of the metal, and by turning the handles of the bench, the wire is gradually produced, by the stretching of the metal as it passes through the holes of the plate. The wire, which is coarse, is then heated to make it soft; for it becomes very hard and brittle during the drawing process: the method of softening it is called "annealing." When cool, its end is filed down so as to allow it to pass through a *smaller* hole than that through which it was first drawn. The drawing process is then used; and thus, by drawing it successively through holes in the draw-plate, each smaller than the previous one, almost any fineness of wire may be produced. We have seen platina and gold wire thus made which were not coarser than a human hair.

The uses of wire are very numerous—for example, it is employed for making pianoforte and other strings for musical instruments, fencing for parks and fields, bird-cages, fire-guards, &c. Two of its most important uses, however, are those of needle and pin-making trades, which we shall next describe.

Gold-plated wire, &c., used for jewellery, gold lace, &c., is produced by first gilding a silver or copper wire, and then drawing it through the draw-plate. The gold may thus be stretched out to almost any degree of fineness, and yet be distinctly seen as colouring the wire.

THE NEEDLE-MAKER.

In the previous trade we have described the methods adopted for converting bars of any metal into wire. The needle-maker, however, confines himself entirely to steel wire, for that alone possesses the properties which are required in a needle used for sewing purposes.

In ancient times needles were made of bone, wood, bronze, gold, &c. They were of very rough manufacture, but exceedingly expensive; so much so, indeed, that estates have been held in this country, subject to the annual payment of one or two of these then costly articles. Like many other trades, the growth of needle-making has been confined to families and special localities, and at the present time the country round Redditch and Studley is the centre of the trade.

We shall now describe the process of making a needle, using freely for the purpose a description attached to machinery shown in the Exhibition of 1862, and employed by Mr. A. Morrall, of Studley Works, Warwickshire, to whose family and himself we are much indebted for the perfection of the modern methods.

The needle-maker receives the wire in the form of rolls about three feet in diameter, the size or thickness of the wire depending on that of the needles to be made. He then puts two or three rolls together, and cuts them through with a large pair of shears. From the lengths thus obtained he cuts off as much as will be sufficient for *two* needles: this is a point which must be borne in mind, because the process depends considerably for speed, &c., on this method.

The wires are next straightened by placing from ten to fifteen thousand within two iron rings, which keep them in the form of a bundle. This is placed in an oven and made red-hot; and while there, the bundles are rubbed with a curved bar of iron until all the wires are rolled or pressed each into a straight line.

The next step is that of pointing the wires, which is done by pressing each end against a dry grindstone. They are then washed, dried over a fire, and placed singly between two dies or stampers, to flatten the wire in its middle, and form the head of each needle, into two of which the wire will shortly be made. At the same time the place of the eye, and that at which the wire is to be broken, are also marked.

The wires are then taken to a hand-press, and the eyes of the two needles punched out at one stroke. The wires are next given to children, who gather together about fifty of them, so that the workman may remove, by means of a file, all rough edges produced during the operation of punching. The wires are now broken at the middle, and thus *two* rough needles are produced.

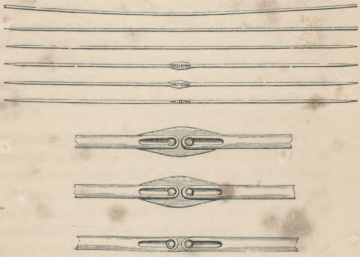


PLATE 12.—STAGES IN NEEDLEMAKING, p. 150.

After the tops of the heads and the inside of the eye have been filed, to smooth them, the needles are "tempered;" that is, the metal is rendered of such a quality as will permit it to bend without being broken. This is done by first hardening it. For this purpose the needles are ranged in quantities on iron plates, which are then placed in a furnace. When red-hot, they are taken out and thrown into a vessel containing oil or water, being afterwards heated on a slow fire in the liquid, and gradually cooled. Many of the needles will have become crooked, and such are straightened by striking them on an anvil by a small hammer. Polishing is the next process; and this is done by putting a large quantity of needles into a canvas bag, with oil, soft soap, and emery powder, in which they are worked for about a week. They are then removed, washed in hot water, and dried in saw-dust.

After being sorted, they are spread out in a line on a piece of wood, the heads projecting over its side, and the next step is to burnish the eye so as to prevent it cutting the thread. The heads are first softened by placing them on a red-hot iron, and are then rubbed with the burnisher. The finishing process is that of completing the polish, which is done by pressing the needles against a wheel covered with prepared leather, and called a "buff," which is kept in rapid movement.

The needles being now finished, are counted, five at a time, wrapped up in paper, and packed up in ten lots of twenty-five each, when they are ready for sale. It is stated that one sovereign's worth of steel is converted into seventy pounds' worth of needles. About one hundred million of needles are made weekly in the needle district, and above ten thousand persons are dependent on the needle manufacture for their daily bread.

There is a considerable variety of needles made each of which is suitable for special purposes, and have an individual name in the trade. Thus, "sharps" are those generally known as sewing needles, "short sharps" are used for coarser work than the former. There are also "blunts," "straws," "harness," "darning needles," "netting needles," "bodkins," &c., names with which many, but especially our lady readers, will be completely familiar.

We have thus traced the methods employed in producing one of the most useful articles of our domestic life, and on which depend so many objects of dress, and the employment of thousands of our fellow-creatures in the trades of the tailor, dressmaker, &c. With these we have already described the "sewing machine" at a previous page (see page 88). In this instrument a needle is also used, but of a different construction to those we have just been speaking of. It is made, however, in a precisely similar manner, and therefore does not require a separate description.

In former times needle-making was a manufacture highly injurious to the workman. This was owing to the fine particles of steel, which are thrown off the grindstone during the polishing of the points, being breathed by the workman, and entering his lungs, produced serious and often fatal diseases. Strange to say that, although many attempts were made to remedy this, the men were urgent in opposing all improvements, because they thought that if the danger were lessened, their wages would also be lowered. They earned high wages, and spent much in drink, so shortening their lives. Of late years, however, fans have been used over the grindstones, and thus the dust is driven away from the workman. His health is thus preserved, whilst any supposed loss of wages has been prevented by the saving of his time, which formerly was much lost through frequent illness.

We shall next describe the making of pins, as a fitting subject in connection with the needle manufacture.

THE PIN-MAKER.

We have seen that the needle-maker exclusively employs steel wire for the material of his trade; but the pin-maker chooses that made of brass as most suitable for his purpose. This wire is drawn in the manner already described under the head of the "Wire-drawer," and is cut into lengths by the pin-maker—at first sufficient to make several pins. The ends of each piece are then sharpened by turning them round whilst being pressed on the edge of a revolving grindstone, and when sufficiently sharp, as much of the piece is cut off at each end as will be sufficient to make two pins. The remainder is similarly treated until all the wire in the piece has been thus converted into headless pins, or perhaps more correctly into wires, blunt at one end and sharpened at the other.

The next step is to put the head on to the pins. This was formerly done by twisting a piece of thin wire round another of about the size of the proper pin, so that a little bead of wire, hollow in the centre, was formed. These little beads were converted into pin-heads by the workman pressing the pointed end of the rough pin into a basin of the wire beads. On one slipping on, it was passed to the blunt end of the pin, and by means of two or three taps of a hammer it became fastened on. If our young readers can find an old pin, they will easily learn how this head was formed. But when made in this manner the heads frequently slipped off, as many of our older readers will remember to their cost. At last "solid-headed pins" were invented, and in these the head is formed by making the pin a trifle longer than it is intended to be. The blunt end is then compressed in a machine having a cone-like opening, and the wire whilst being pressed expands to fill up the hole, and becoming wider than the pin, forms its head.

The pins next require whitening, and this is done by "pickling" them in acid water, and then boiling them in a vessel containing pieces of tin and some tartar—a coarse kind of cream of tartar. After a short time the tin completely coats the pins, and renders them beautifully white. They are then washed, dried in hot bran, and placed in the hands of women, who sort them, and afterwards fix them on paper, or pack them in quantities, when they are to be sold by weight.

THE CUTLER.

Sheffield is known all over the world for its cutlery—a term applied to such articles as razors, knives, &c.; but before describing the manufacture of these articles we must explain to our young friends how steel—the staple commodity of Sheffield—is produced from iron.

When describing the production of metals from their ores (see page 138), we took iron as an example, but only proceeded so far as to explain the production of "pig iron;" we must therefore continue our description from that point, and show how the raw metal is converted, first into wrought iron, and subsequently into steel.

"Refining" is the first operation in these processes. The pig iron is broken up into pieces, which are thrown into a shallow trough, and exposed to an intense heat. As the iron melts, the air acts on it, and burns away a large proportion of the charcoal or carbon it contains. The melted iron is then run off, and after being again broken into pieces, is cast into another furnace, called the "puddling furnace." In this it is again melted, and also kept constantly stirred up by the "puddler," until it becomes of a pasty consistence, which arises from the further action of air and heat. It is then removed in masses called "blooms," weighing about sixty pounds each.

One of these lumps whilst red-hot is then placed on an anvil, and struck by powerful hammers driven by a steam engine. By this it is beaten into a flat bar, which is afterwards passed repeatedly through rollers. This operation drives out a large amount of impurity, and the iron becomes gradually tougher, assuming the condition called "malleable," and is converted into a bar.

A number of these bars are then welded together, by first heating them in a furnace, and then passing them through rollers. By this last process the metal is converted into "wrought iron," and is drawn into bars, rods, sheets, or other form of that material: railway bars are thus produced.

Iron varies much in its quality; partly from the nature of ore from which it is obtained, and also from the processes that we have described as used in its manufacture. Hot and cold-blast iron are so named from the circumstance of heated or cold air having been used in the manufacture of the "pig;" and much difference of opinion has existed as to which is the best. Mr. Bessemer has invented a singular process for preparing wrought iron, which saves much trouble, and converts the metal into the wrought state immediately as it is produced from the ore. He does this by re-melting the metal, and driving into it common air, which causes the burning away of all impurities, and the production of a material almost equal to the best "wrought iron." But despite all the different processes used with iron obtained in this country, it is commonly inferior to the Swedish; hence that is chiefly employed in the manufacture of steel, which we shall proceed to describe in detail.

Steel is made by a process called "cementation," and it is effected by heating the best bar iron in boxes with layers of charcoal, which is gradually absorbed by the metal. This entirely changes the character of the iron, and partly reconverts it into the "cast" kind, but also endows it with far different properties The workman watches the process, and constantly takes out a bar to see its progress. When he judges it complete, the bars are removed. They present a kind of blistered appearance, and hence the name of "blistered steel," which is only employed to make common steel articles.

Shear steel is produced by breaking bars of the blistered kind up into pieces a foot or so long, and beating them out by a powerful hammer. They are then made white-hot, and hammered together until they form a solid mass; and after this the steel undergoes the operation of "tilting." This consists in hammering the bars of shear steel whilst heated to a low temperature, and thus an even and close texture is imparted to the metal. Cast steel consists of common steel melted in crucibles, a very great degree of heat being employed. The metal is then cast into ingots, and afterwards rolled into sheets or bars, according to the purpose to which it is to be applied. Mr. Bessemer has patented a method of making steel by first preparing the iron in the manner described at page 157, and then adding to it some melted German iron, containing exactly the proportion of carbon or charcoal required to convert the metal into steel. On this being added, the contents of the vessel are instantly cast into mould, and steel of excellent quality is produced. Railway bars made of this metal have been found very durable.

Having thus described the manufacture of the raw material of the cutler, we may next proceed to describe how he makes knives, razors, swords, &c.; for although these differ in shape, and in their uses, the modes of manufacture in most respects are alike.

Table knives are forged either out of shear or cast steel, the last being used for the best kind. A piece of the steel of nearly about the size of the knife is made red-hot, and hammered until it is of the required shape, the tang or end which secures the knife to its handle being made separately, and afterwards welded to the blade. This is then tempered by heating it red-hot and plunging it into cold water. It is afterwards ground on a grindstone, polished, and the handle fitted to it. The handle is either of horn, heated and then compressed to a proper shape, or of pieces of ivory, bone, or pearl, cut into that form. Razors are similarly made, but greater care is shown in selecting the steel, and also in tempering it, for if too hard the blade is not easily sharpened and is liable to break, whilst if too soft it would not keep its edge. When a razor is viewed by a microscope of great power, the cutting edge exactly resembles a saw.

Pen-knives, planes, chisels, &c., are all made in a similar manner to what we have just described: in fact, we may state that all articles made of steel have to undergo similar processes—namely, that of heating, shaping by the hammer, grinding, and polishing. The same applies to swords, which are, however, made from pieces of steel forged of a size to produce one from each, and called in the trade "sword-moulds." The valuable quality of a sword consists in its elasticity—that is, in its power of returning to its previous shape after the point and handle have been so bent as to nearly touch each other; and for this quality the Damascus and Toledo blades have been long noted.

Scissors are made by forging the blade portion in a similar manner to what has been described for knives. The handles are made by punching the centre out of a steel plate, and enlarging the hole by inserting tools in it; or the cheapest kinds are cast in a mould and afterwards ground and polished.

The two blades are joined together by rivetting—that is, by inserting a pin of metal in holes at the parts they are to open, and hammering the pin so as to form a shoulder on the outside of the blades when they are joined together.

THE FILE-CUTTER.

In most manufactures of metal, files are used to remove rough surfaces, to fit pieces together by smoothing them at the parts where they are to be joined, and also frequently to give them a kind of rough polish: indeed, the file is one of the most commonly used instruments of the engineer and machine-maker.

A piece of bar steel is forged by heating, and then hammering it into the required shape; and this is either square, half-round, or triangular. On the shape being formed, the metal is annealed by heating and cooling it gradually, and when quite cold it is ground to a level surface. The teeth have then to be formed; and this is done by holding a tool of hard steel across the metal, and striking the tool with a hammer; a "dint," or long but shallow cut is then made in the steel, and so each tooth is successively produced over the surface. After all the teeth are cut, the file requires hardening; for its value as a tool depends on its hardness. For this purpose it is heated red-hot, and plunged in this condition into cold water containing ale-grounds and other mixtures. It is then dried and fitted for the use of the machinist.

THE SAW-MAKER.

One of the most useful instruments to the carpenter is his saw; and although there are many kinds, varying in their size and in the objects to which they are applied, they are all made on the same principle.

For the best kind sheets of "cast steel" are used, and they are cut up into strips, by means of shears, to the size which the saw is intended to be. The edges on one side are then ground down. The teeth are then cut out by means of punches, of the shape of a triangle, worked in a press; and by this, little pieces of the metal are cut out, the sides of the metal so left in fact forming the teeth. The saws are then hardened by heating them in an oven, and whilst still hot, plunging them into oil. They are hammered whilst hot so as to make them straight, and afterwards planished by beating them on a polished steel anvil, by which they are rendered of even texture throughout their substance. The edges of the teeth are then ground, by applying them to a rapidly revolving grindstone. After the saw has been again hammered, to remove any twist caused by grinding, &c., the teeth are "set," by beating every other tooth out of a straight line, by a blow with a hammer; and thus the saw is complete.

THE NAIL-MAKER, OR NAILER.

Simple an object as a nail may appear, it ranks amongst the necessities of our lives; for without it our furniture, houses, &c., would with difficulty be put together. Like other metal trades, the manufacture of nails is chiefly confined to a district, and the towns of Dudley, Walsall, Wolverhampton, &c., have long been noted for the manufacture.

There are three kinds of nails—namely, "cast," "wrought," and "cut." The first, which are coarse and brittle, are made by casting the metal in moulds, and are chiefly used by gardeners for fixing fruit trees to walls, their peculiar nature not fitting them for use in any work requiring strength.

Wrought nails—those most largely used—are made from rods of iron resembling thick wire, produced by cutting sheets of iron with slitting rollers, which divide the metal into strips of the thickness of the nail, and of any chosen length. The nailer puts one end of the rod into the fire of a small forge, and when sufficiently hot, removes it to an anvil, where, with a few blows of a hammer, he shapes it into a nail, cutting off sufficient length for that purpose. Of course, the nail thus made is without a head or shoulder, but this he produces by hammering the thick end until the required shape is obtained; hence, in making wrought nails, no machinery is employed by the workman, for he depends entirely on his own dexterity in the use of the hammer and anvil.

"Cut" nails are made by cutting up sheets of iron into a width equal to the length of a nail; these being afterwards cut up into pieces in a slanting manner, so that one end of the nail is sharp whilst the other is broader, and therefore blunt. "Brads" used by carpenters, and nails used by shoemakers, are thus made.

Screws are made in an entirely different manner. A piece of thick wire, of the size of the screw, is cut off, and the head is formed by compressing one end of the metal, that portion being afterwards turned in a lathe to make it smooth. The notch which we see across the head of the screw, and into which the screw-driver is pressed when the screw is driven into wood, is cut by means of a very ingenious machine. The "worm" or "thread" of the screw is then produced by putting the piece of metal in a lathe, and making it rotate rapidly. A hard steel tool is pressed against it, and gradually forced from the shoulder to the intended point; and thus the spiral part is cut out, and the screw completed.

Nails vary much, and have different names applied to them—as "tacks," "brads," "flooring," "scupper," "clouts," "dog," "rose," &c., according to the purpose for which they are applied. Hob nails are generally about six inches long, and between this size and the "sparable," a small kind used by shoemakers, many different forms and sizes are produced, the mode of manufacture, however, being some one of those we have just described.

LEAD PIPE AND SHEET-MAKER.

Lead pipes are largely used for conveying water to our houses, and lead sheet is much employed in roofing them, and for other purposes. It would be naturally thought that lead, being so soft a metal, would be easily worked; but that fact rather hinders than helps the workman, for it makes the metal less tenacious than others, and thus renders peculiar processes necessary in treating it.

To make lead sheets, a quantity of the metal is cast into an oblong thick piece—a block. It is then rolled between heavy rollers, which, whilst they lessen its thickness, increase its length. The rolling is continued until the requisite thinness is attained, the thickness of the lead being diminished a little at each time it passes through the rollers. In making vessels of sheet lead, the edges are soldered together by melting a mixture of lead and tin at the joints, and running a red-hot iron over them. Sometimes, however, as for roofs of houses, the sheets are fastened together with copper nails, and their edges are beaten with wooden mallets to keep them watertight.

For making sulphuric acid, large rooms are built of lead sheet; but in this case, as the solder would be destroyed by the acid, the sheets are united by melting together their edges. For this purpose the powerful heat afforded by burning the two gases producing water is employed—or, in other words, the oxy-hydrogen blow-pipe; and the joints are thus made of the same metal as the sheets themselves.

Lead pipes, such as we use for conveying water, are made by first casting a short length of pipe in a mould, and having a bore or opening in its length of the same size as the intended pipe, but the solid metal is much thicker. The pipe is then "drawn" in an exactly similar manner as wire is drawn, a description of which is given under the head of that trade, the only difference being that the pipe is of course hollow, whilst the wire is drawn solid. Lead pipes are joined together by a peculiar method of soldering, which is generally done by persons following the separate trade of the plumber.

THE SHOT-MAKER.

The manufacture of shot for use in guns is a very interesting example of a law very common in its action, and which we may specially notice in the planets. They are all nearly round, which arises from the attraction which keeps their parts together, acting from their centre; and from this cause any liquid falling from a height at once takes a globe-like shape, as we may notice in the drops of rain form the clouds, or in water spilt little by little from the spout of a jug. The maker of shot avails himself of this singular property, and proceeds as follows:—

A tall tower, called a "shot tower," is first built, at the top of which the lead is melted. In the floor of the top of the tower is a large basin-like vessel, pierced with small holes. The lead whilst being melted has a little arsenic added to it, which tends to harden it. It is poured in a molten state into the vessel just described, and the lead rapidly passes through the holes. As it descends it assumes a round shape, and at last falls into a vessel of water, placed at the bottom of the tower. On being removed from this, the shot are dried, and then sifted, so that they may be assorted into different sizes, according to the purpose for which they are intended. They are separated from badly shaped pieces by running them down a board placed in a slanting position. Of course, the perfectly round shot will run off rapidly, and to a greater distance than those which are oblong, egg, or pear shaped. The latter are re-melted, but the good shot are shaken up with a little black lead, and thus obtain a black glossy appearance.

Bullets are cast in moulds made of iron, and of the same shape as the bullet is intended to be; and this is done by pouring melted lead into the mould. Shot for cannon, or, as they are more usually called, cannon balls, are cast in moulds of sand, &c., cast iron being the material employed. Bomb-shells, intended to be filled with gunpowder, &c., and fired from a mortar, are similarly cast. Shot for rifle guns or rifles are also cast in a mould, but of these we shall have to speak more fully in connection with the trade of the gunmaker, and the manufacture of cannon.

GOLD, SILVER, SHEFFIELD, GERMAN SILVER, AND BRITANNIA PLATE MAKING.

Plate is a term applied to articles used for domestic purposes, made either out of the precious metals, as gold and silver, or else from alloys intended to imitate them in external appearance, especially in respect to the polish, colour, &c. We shall therefore include in this a description of gold, silver, "Sheffield," German silver, and Britannia metal articles, because whilst they differ in the material, they are all manufactured or made up in a similar manner. We must commence, however, by giving a brief description of the sources of the metals employed in these trades.

Gold is found in nearly every country, but with few exceptions in very small quantities. Thus Wales produced several thousand pounds' worth in 1861, specimens of the metal being shown at the Exhibition at London in 1862. It is also found in some parts of Scotland and Ireland, and in many countries of the continent of Europe. But our chief supplics are now drawn from various parts of

Australia, and British Columbia and California, in America—sources discovered within the last twenty years, but which have yielded far more than even the best of the older mines.

Gold is found in grains and nuggets, the former being very small specks like sand, whilst the nuggets sometimes weigh several hundred ounces. The grain gold is obtained by washing the sands of rivers in a "cradle," which is simply a vessel kept, either by the hand or machinery, in constant motion. Water is allowed to flow into it and remove the sand, whilst the gold being far heavier, falls to the bottom, and is collected as a yellow powder. This process is called "gold-washing." Either in this state or the nuggets, the gold is quite pure, and requires no "reduction" like that necessary for preparing the common metals from their ores.

Silver is rarely found in a pure state, for it is often combined with other metals, and with sulphur, from which, however, it is separated by mercury, which dissolves it; the latter is then driven off by heat, leaving the silver in a nearly pure state. Our chief sources of this metal are Mexico, Chili, and Peru; but a large quantity is obtained from our own lead mines, silver being mixed more or less with all lead found in Great Britain.

Copper is used to alloy or mix with gold and silver, and serves as the basis or foundation of "plated goods." It is largely produced in the ore state in Cornwall, Australia, &c., and is reduced by roasting, fluxes, &c. Rolled out into plates, it is made into many useful articles. Gold and silver are alloyed with it, to give them sufficient hardness in coin; and the "Sheffield plate," of which we shall shortly speak, is made of plates of copper on which a silver one has been first soldered. The two are then rolled out into sheets and thus one side is "plated" with silver.

German silver is an alloy of nickel, zinc, and copper, metals well-known to our young readers, excepting, however, nickel. This is very much like iron in most respects, except that it melts at a much lower heat.

Britannia metal is an alloy of brass, tin, bismuth, and antimony. The last of which is also much used in making printers' type, of which we shall have to speak hereafter.

We have thus described the nature of each of the materials chiefly used in making "plate." They are all prepared for the maker by first rolling them into sheets of variable thickness, and the following is a description of the general method of manufacturing them into useful articles:—

A design of the intended pattern is first drawn on paper and afterwards modelled in wax. This forms the model from which the operator works. Sometimes this is done by casting, when the metal to be worked is cast in a mould made from the original pattern. In other cases the metal is pressed into the designed shape by means of dies, in which are engraved the reverse of the intended pattern. The metal is placed under the die, and the latter is forced into it by means of a screw-press, somewhat after the ordinary mode of coining, which we shall have to describe hereafter. When the required shape is given to each piece of the article, they are neatly soldered together, and afterwards polished and burnished by rubbing them with a hard stone.

Silver articles, being of the same material throughout wear constantly of the same colour; but Sheffield plate, being composed of copper only, coated with silver, show the former metal at their edges after being worn for some time. This is obviated by fixing real silver edges backed with a white metal alloy, so that when the silver is entirely worn off, the white metal shall appear in place of the yellow copper.

At the present day, however, most plated articles made after the manner we have described, have been entirely replaced by the beautiful art of electro-gilding and electro-plating, which we shall accordingly now describe.

THE ELECTRO-PLATER AND GILDER, AND WATER GILDING.

Amongst the numerous uses to which the precious metals are now put, that of electro-plating and gilding is one of the most universally spread. But a few years have elapsed since this new method of covering articles with gold and silver was discovered, but now its application forms a very important and profitable branch of business. We are sorry to say, however, that like many other valuable discoveries, it has had its bad uses; and thus we find that coiners of bad money largely used it to cover over the base metal—as tin and pewter—of which they make bad coin.

But our young friends will not be able to understand the nature of the process unless we give a short explanation of the science of the whole. We shall do this in as simple a manner as we can, and suggest an experiment or two, to teach them partly the art.

If we put a half-crown on one side of the tongue, and a piece of zinc on the other, nothing extraordinary will be perceived. But if the metals are made to touch, by bringing their edges together, then a biting sensation is produced. Why is this? The fact is, that at the moment they touch, electricity—the same power which causes the thunderstorm—is set free, and travelling *from the zinc to the silver over the tongue*, and back again to the zinc, at the part the metals touch, a current is produced, which is exactly that by aid of which the electro-plater works.

Now, this simple affair is a small galvanic battery. That which the electro-plater uses is made of larger plates of metals, and he employs acid and water instead of the moisture of the tongue. A wire is carried from each plate of the battery into a trough holding a solution of copper, silver, or gold, according to the metal he wishes to deposit. The article to be plated is attached in the trough to the wire coming from the zinc of the battery, and opposite to it is a plate of the metal dissolved in the liquid of the trough. Now, as soon as all this is properly arranged, the electricity of the battery travels from the silver plate of it to the plate of metal by means of the wire, and reaching the liquid, dissolves off a portion of the plate. This part dissolved off is carried to the article which is to be plated, and is there thrown down again as a metal to any thickness that may be desired. Thus as much is dissolved off one plate as is thrown down on the article, and all this is due to electricity produced by two metals with a little acid and water.

Pe.haps a simple experiment in which the same principles are involved may teach our young readers a little more of the interesting process. If a polished piece of steel, such as a knife blade, be dipped into water in which some blue vitriol — sulphate of copper—has been dissolved, it will soon become completely covered with copper. Now, this is owing to a number of little galvanic batteries formed by the impurities in the iron, which act in exactly similar a manner to the larger and separate batteries of the electro-plater. By such means dishonest persons often coat iron nails with copper, and sell them at a high price, as if they were that metal. In olden times the alchemists boldly stated that they had discovered a method of turning iron into copper! But this is false, for all that takes place is just that which we have explained about the battery;—as much of one metal is dissolved off as is thrown down or deposited.

The electro-plater first carefully cleans the article from all dirt, brushing it so as to remove everything from the surface. If it be a metal body, he dips it into an acid solution, so as to remove a small portion of the metal, and thus to get a perfectly clean surface. The object is then hung by means of a wire in the trough holding silver dissolved by a salt called cyanide of potassium, and facing a silver plate, the latter being connected with the silver plate of the battery, whilst the object is in connection with the zinc plate. Silver is instantly deposited; and after a sufficient thickness has been thrown down, the article is removed, washed, polished, and burnished, when it presents even a finer and more brilliant appearance than a common silver object, because the electro-plated surface is of perfectly pure silver.

If a gold plate and solution are employed, the article becomes gilded, the entire process being precisely similar to that of electro-plating, except in the metal and solution.

We have said that electro-plating, &c., is greatly used, and we can scarcely attempt to mention even but a few objects thus coated with the precious metals. Tea-pots, candlesticks, brooches and jewellery of all kinds, vases, kettles, and an almost endless variety of such matters, when thus treated, become to all appearance converted into silver or gold, and the coating wears for a long time. It can always be renewed by the same process, and hence the value of this method of gilding and plating.

Had we space, we should have been happy to have taught our young readers how to obtain copies of metals in copper, silver, gold, &c.; but leave them to consult other works devoted to a fuller description than we can here give.*

Formerly objects were gilded and silvered, by covering them with an amalgum—that is, the silver or gold, dissolved in quicksilver, or mercury, was spread on their surface; and, on subsequent exposure to heat, the mercury was driven off, leaving the precious metals as a thin coat on their surface. This was an uncertain method, and proved exceedingly injurious to the workman, from the fumes of the quicksilver, which are highly dangerous. This plan is called "water gilding," but it is now rarely followed, because the electro process is better, quicker, more certain, and the deposit lasts much longer in wear.

* The *Magic of Science* by the author of this work, and published by Messrs. Griffin & Co., affords all details and necessary instructions for this purpose.

THE GOLD-BEATER.

Amongst other methods of converting the metals into useful forms, that of beating them out into leaves must be mentioned. Gold, silver, copper, zinc, &c., are thus treated; but as the methods followed for each metal are very much alike, we shall only describe the labours of the gold-beater.

The gold is used not in a pure state, but alloyed or mixed with copper; and this is done by melting about one and a half ounces of the common with ninety-eight and a half of the precious metal. This is done in a crucible placed in a powerful furnace. As soon as the two metals are completely melted, they are cast into blocks called ingots. The ingots are then passed between steel rollers, and thereby flattened out into a kind of metal ribbon. This is then cut up into pieces, and hammered on an anvil until an inch square does not weigh more than six grains. The squares are then made up into a packet, a piece of vellum of about four inches square being placed between them. About 150 are then piled together, and the whole being covered with a parchment envelope, the packet is beaten on a smooth stone with a heavy hammer. On removing the squares, formerly of one inch, they are found to have extended sixteen times their previous size—that is, each covers the piece of vellum four inches square.

Each piece is then divided into four, and placed between pieces of "gold-beater's skin," which has been prepared from the intestines of the ox: it is the same as that commonly sold at the chemist's shop for covering cuts and wounds on the fingers, &c. The pieces are again packed up, and beaten until they have extended four times their previous size, when they are again cut up, re-packed in skin, and beaten until a sufficient thinness has been arrived at. Some idea of the fineness may be arrived at when we inform our young readers that it would require three hundred thousand sheets of the ordinary gold, as used by gilders, to make a pile one inch high! When finished, the leaves are removed from the skins, and packed in books of twenty-five leaves each.

Silver, platina, copper, and zinc, are also thus beaten out, but not so thinly as in the case of gold. Dutch foil is made of the leaves of copper and zinc, the former of which is often substituted for gold leaf in cheap work. Chimney glasses, picture frames, signs over shops, and a great number of objects, are gilded by merely painting the surface by means of a kind of varnish called "gold size." On this the leaf is pressed, and forced to a flat surface by gently pressing a little cotton wool, or other soft substance, on its surface. When the size has dried, the gilder "dusts" the gilding over with a light brush, which removes all the useless leaf, and completes the process.

Surfaces thus gilded present all the appearance of gold, and the plan is much used for various ornamental purposes. The gilding of metals, called "water gilding," has been described under the head of electro-plating and gilding, as it is conducted on a very different plan (see page 174).

COINING.

In the early days of our world's history, when the use of coin was unknown, men "bartered" goods with each other; that is, they exchanged one kind of goods for another, settling the value of each according to their respective wants. This plan is still followed by savage nations, and thus beads, some kinds of shells as the cowry, cotton cloths, and a great variety of articles are exchanged by the European trader for gold, ivory, and many other precious commodities, with the natives of many ports of the coast of Africa, and other places, where the use of money is still unknown.

But amongst civilized nations this method is absolutely impossible, because the transactions or businesses are very extensive, and also on account of different goods varying constantly in their value in respect to others. Thus, a pound of sugar may at times be of the same value as a pound of bread; but when wheat is scarce, the bread may attain a price equal to twice that of the sugar, because the latter can be done without, whilst the bread is essential to our lives as an article of daily food. From such and similar considerations, the use of money, doubtless, became first common amongst men.

In choosing the metal of which coin is to be made, several points must be kept in view. It must be sufficiently hard to bear the wear and tear of constant exchanging. It must also have an intrinsic, that is, individual value of its own; and lastly, to ensure that its individual value is almost the same, so far as its purity is concerned, it should be stamped or marked by the government, or other body by which it is issued. Its character is thus guaranteed; and, as an instance of the kind, we may mention that the British sovereign, although only current in our own country, is readily sold in any other, because the stamp or impress on its faces shows that it has been issued from the British mint—a source considered as beyond the influence of any base motive, or permitting the chance of loss to the buyer.

Various metals are employed in different countries, gold, silver, and copper being those usually adopted. In Russia, however, platina, a hard, heavy metal, resembling silver, is also used. Metals are never employed in a pure state; for they require to be alloyed; gold and silver, at least, being far too soft in that condition for the purposes of coin. The English standard gold in the form of sovereigns is of the value of £3 17s. 10½d. per ounce troy of 480 grains, and contains 22 parts of pure gold, alloyed with 2 parts of copper. A pound of standard silver is coined into sixty-six shillings, and it contains 12 parts of pure silver, mixed with 1 part of copper. The names of our coins are,—gold, the sovereign and half sovereign; silver, the crown, half-crown, florin, shilling, sixpence, fourpenny, and threepenny pieces. Other countries have various denominations of coins; for example, in France the franc takes the place of our shilling; in Germany, thalers, &c., are used; in Spain, dollars; and similarly, the same kind of coin is common in Portugal. The name of each may be readily learned by referring to any book of arithmetic, and thus our space may be spared unnecessary encumbrance.

The operation of coining comprises numerous processes, which are chiefly those of alloying the pure metal, casting the ingots, rolling them into bars, stamping out the coin, sorting and polishing them, and testing their weight. The gold is melted in large crucibles or earthen vessels, made of strong clay, which resists the action of the most intense heat. The crucibles are placed in a furnace, and the copper and gold being melted together in the proportions already mentioned, are, when completely fused, poured into ingots. These ingots are remelted, and again cast; they are then rolled into bars or strips of nearly the width of each coin, and are ready for the coining press.

This apparatus is precisely similar to that used for making medals, only it is of far more perfect manufacture, and varies in several minor details. The matrix, die, or mould by which the coin is cut from the strip of metal, is made of steel, and is formed of two parts, in each of which a reverse of the coin is engraved; that is, the figures which are *raised* on the coin are *cut into* the matrix, die, or mould; and hence, when the metal strip is pressed into the mould, the latter produces a raised figure on the coin. A common engraved seal is made on exactly the same plan, and just as that affords a raised copy on melted sealing-wax, so the mould used in coining gives a raised surface on the metal pressed into it. The metal is forced into the mould with great pressure, in some cases by means of a screw, and at others by the pressure of the atmosphere; in either case, of course, great force is required; and for this purpose powerful steam engines are employed. The coins are rapidly produced by passing the metal slips into grooves; and, as at each time of the descent of the punch or matrix a coin is produced, it is at the same moment removed, so that a fresh piece of the metal slip may be similarly converted into coin. The process is therefore continuous so long as metal is supplied to the press. After the coin is thus thrown off, which is done in a complete state, it requires annealing to render it less brittle; and this is done by heating it. The tarnish, if any, is then removed, and the coin presents the appearance so well known. As gold is of great value, the weight of each coin is ascertained by a most curious and accurate machine, which weighs them very rapidly and correctly; and thus, if a number of sovereigns be weighed as received from the mint, they will vary but very slightly in weight from each other.

The "milling" round the edge of each coin is produced by fine grooves, which are made round the rim of each die or mould. This process was formerly effected after the coins were made or "struck." It is now, however, produced at the same time as the coin is made.

Such is a brief account of the mode of coining, as followed by the British mint, which is the most complete establishment of the kind in the world. Silver and copper coins are produced in a similar manner, and need not, therefore, any further description.

Bad or base coin, which is often so largely and wickedly passed by "coiners," as persons who make it are called, is manufactured from a mixture of lead and tin, of tin, iron, &c. Generally speaking, a mould of the true coin is made in plaster of Paris, and into this mould melted tin or pewter is poured. This alloy assumes the form, &c., of the true coin, but is never so accurate or beautiful, the edges being far less sharp and the milling incomplete. To prevent the smell of the tin being noticed, the base coin is coated with silver by the electrotype process, in the manner we have already described at page 173, and thus a coating of pure silver is afforded so as to completely deceive the eye in the case of spurious or bad coins. If such, however, be placed in a wedge of brass, and strongly pressed, they are readily bent, because they are soft, whilst a real silver coin, being harder, cannot be so bent. Another method is to bite them with the teeth, which will easily pass into, and make a dent in the bad coin, whilst the silver will remain untouched. To overcome these modes of detection, some clever coiners have made small pieces of money from sheet iron, coating them with silver, as just mentioned; but the metal is too hard, and gives too much trouble to make the process pay.

Sovereigns have of late years been ingeniously diminished in value by slitting a true coin, and soldering in the centre a piece of platina. Now, as this metal weighs nearly the same as the gold—bulk for bulk—it is impossible to detect such a bad coin by merely weighing it; and the chemical properties of each metal are also so alike that it would be difficult to employ chemistry in the detection of the fraud. Hence this kind of fraudulent dealing has been very successful, and "pays," as it affords a profit of from three to four shillings per pound to the rogue who follows it. The ring of the coin thus made is, however, different to that of a true coin, and to a practised ear affords a method of detecting the fraud. On more than one occasion these base sovereigns have been detected by striking them forcibly on a table, when they have separated into two pieces, owing to the bad soldering which had been employed in uniting the parts together.

THE TINSMITH.

Amongst the numerous workers in metal, one of the most useful is the smith, by whose labour so many of our domestic and other articles are fashioned and repaired. The terms "tin," "black" and "white" are applied to each branch of the business, according to the separate duties of each, or the metal used by them. We shall give a short account of each of these trades, in the order we have named.

The tinsmith makes and repairs such articles as tin kettles, pots, &c., and he uses not tin alone, but iron plate coated with that metal. For this purpose, sheets of iron are carefully cleaned from their rust or oxide, and are then dipped into a vessel containing melted tin. This metal soon coats the iron, and produces on it a beautifully white polished surface. Galvanized iron, so much used for making roofs of large buildings, temporary houses, churches, &c., pails, and other articles, is made in a similar manner, with the exception that zinc is used in place of tin in the galvanizing process. Whether the iron be coated with tin or zinc, the object is the same—that of protecting the metal from the action of air and water, and of thus rendering it fitter for the uses to which it is to be applied.

We may best explain the trade of the tinsmith by describing the methods by which he fashions his articles. Supposing, for example, the instance of a saucepan. He beats out on an iron or steel anvil two sheets of tin until they assume the shape of its sides. He then cuts out with a pair of shears another piece to form the bottom, and one a little larger to form the lid. This one is beaten in the centre, so that it may acquire a hollow or convex shape. Narrow strips are also cut to form the rim and handle of the lid.

Having thus shaped the pieces of metal, his next business is to solder each together, and this is done by means of "solder" and the "soldering iron." The solder consists of an alloy of lead and tin, and it melts at a low temperature, whilst the soldering "iron" is a piece of thick copper, of a wedge-shape, coated at the end with tin, and fitted with an iron rod into a wooden handle.

The edges of the tin plate are now coated with powdered rosin, the object of which is to keep the metal quite clean, and from the action of the air during the soldering process. The "iron" is next heated, and a strip of solder is placed at the part where the tin sheets are to be soldered together. The heated iron is then pressed on the solder, and melts it. The metal unites with the tin on the sheets, and as it cools joins them firmly together—the solder acting as a uniting substance to each, and making the joints perfectly water-tight. By thus proceeding the bottom is soldered to the cylinder forming the sides, and step by step the entire saucepan is completed.

By such means—of beating the sheets of tin into the proper shape, with a mallet, hammer, and anvil, together with the soldering—all tin articles are produced, the art of the tinsmith consisting in the facility and perfection of the workmanship he applies with his labour.

Sheet zinc has of late years been largely used in place of "tin;" and from the ease with which it is produced in large sheets, numerous articles of domestic use are made from it. It is beaten or shaped in the manner we have already described, and similarly soldered together at the joints. But a few years ago zinc was but little used; it is now, however, extensively employed, not only for the purposes we have named, but also as door-plates for shops, roofing of our houses, in voltaic batteries, for electrotyping, &c. When holes are driven through thin sheets, by means of punches, it forms the perforated zinc used in making safes for meat, &c.

THE BLACKSMITH.

The blacksmith works exclusively with iron, in making articles used for rough work, as, for example, shoes for horses, the iron work of numerous objects used in trade, and for domestic purposes, &c. His business much, or perhaps chiefly, depends on the property of iron called "welding," which we have already explained to be that by virtue of which two pieces of iron heated to a white or high red heat, and hammered together, unite to make one mass.

The implements of the blacksmith are the forge, hammer, file, pincers, &c. The forge enables him to heat the iron, and it is furnished with a bellows, by blowing which the coals are heated violently and the iron softened. When a piece is thus heated, it becomes so soft that it may be bent into any shape; and, availing himself of this, the smith, by means of the hammer and anvil, converts it into any form he may desire.

The whitesmith differs little in his trade from that of the blacksmith, polished articles being chiefly those which he makes and repairs. The operations of each are precisely similar. The metal is heated to soften it; in this state it is hammered to shape it; whilst, by the use of the file, a polish is given to the surface, and sand or emery paper completes the whole process.

The material of both black and white smith consists of iron, in the shape of round rods and flat bars, hoop and sheet iron, the latter being cut by shears into the required shape. Rivets, such as we have already described in this chapter as used by boilermakers, are employed for connecting pieces of metal together, in many instances where welding could not be adopted.

THE PEWTERER.

But a few years ago pewter articles were in very great use, but owing to the improved methods of dealing with other metals, as German silver, Britannia metal, &c., pewter articles have nearly gone out of fashion.

Pewter consists of an alloy of lead and tin, in various proportions, according to the objects to which it is applied. It is an alloy which melts at a low temperature, and hence the pewterer casts his articles in a mould, after a similar manner to that we have already frequently explained in our previous pages. He then turns the rough casting on a lathe, which is a very easy process, because the metal is so soft. The chief articles now made of pewter are pots for the public-house, moulds for the candlemaker, wash-hand basins, plates, soap dishes, &c. Pewter pipe for the gas-fitter is made in a very similar manner to that already described in the manufacture of lead pipe.

BIRMINGHAM WARE, HARDWARE, &c.

It would be impossible for us to describe all the varied manufactures carried on at Birmingham, which has long been the centre of manufactures in metals, and where so many articles of domestic and general use are produced.

Hardware is a term applied to such articles as cast-iron boiling pots, kettles, frying-pans, &c., the body of which is cast in a mould, whilst the handles, shaped by similar methods adopted by the blacksmith, are rivetted on the solid body. The method of shaping the handles and rivetting are described under the head of the trade we have just named. The insides of such vessels are "tinned," by first cleaning them and boiling in them a mixture of salts of tartar, or sal-ammoniac, with water and pieces of the metal tin, a portion of which is dissolved and thrown down on their surface. A similar method is also adopted to that described as that for tinning and galvanizing iron plates, under the head of the "Tinsmith."

Many articles are made by casting the metal separate pieces in a mould, soldering them together, and then turning them in a lathe, a plan employed in making brass and other candlesticks, chimney ornaments, and a great variety of brass articles.

The button trade is also largely carried on. Pieces of metal, of the shape of the button, are stamped out by a die, in a manner similar to that adopted in coining; and the holes are made by drills, which, whilst revolving rapidly, pierce the metal, the rough edges being removed with a file, and the buttons are afterwards polished. Buttons of iron, bone, &c., used for trousers, are thus made; whilst those of a round form, used for coats, &c., are produced by soldering a flat piece of metal on to the shank or holder, and doubling over the top piece a little cloth; the shank and top are then pressed forcibly together, and the button is complete. Metal buttons are gilded in a manner already described under the head of Electro-plating and Water Gilding (see page 174).

PLATE 13.—STAMPING BUTTONS, p. 188.

It will be unnecessary for us to pursue a further description of Birmingham wares, as all the processes employed, and the materials used, have been already mentioned in connection with other metal manufactures, and are really comprised in casting, hammering, turning on the lathe, filing, polishing, &c. We shall therefore only particularize one—the Gunmaker—which is one of the most important trades of the district.

THE GUNMAKER.

The history of man is unfortunately too largely connected with that ot the art of making instruments of destruction; and from the earliest times we learn that war raged on the earth, and that human passions found vent in private and public slaughter of our species. Amongst the most ancient nations, and up to a comparatively modern period, bows and arrows, and pikes were chiefly used for fighting, and the destruction of animals in the chase. The sling and stone were also long and extensively in use; and we learn that, for the purpose of training the youths of the Balearic Islands in the use of this weapon, they were kept fasting until they had "slung" their breakfasts from the top of a high pole. Our young readers will remember that David exhibited his prowess with this weapon in his fight with the giant Goliath, and previously in defending his father's flocks.

One principle is involved in the construction of both ancient and modern arms: it is that of *momentum.* By this we mean that power which a heavy body moving at a slow rate, or a lighter one at a rapid rate, possesses in enabling it to overcome any obstacle. Thus the battering-ram consisted of a heavy bar, the end of which was made by metal cast in the form of a ram's head. This was slung from upright posts by means of ropes, and on being drawn back as far as possible, by men holding ropes, struck a wall or other object with immense force when allowed to bound against it. This is an instance of great weight propelled with little momentum.

In our days the opposite principle is universally adopted—namely, that of little weight, comparatively speaking, but immense rapidity of flight. Thus, by our cannons and rifled guns, we project a ball weighing from 100 lbs., or more, to an ounce in weight, moving at a rate of above 1,200 feet per second. This speed of projection is entirely due to the invention of gunpowder, which, expanding enormously on being set fire to, propels the ball rapidly from the barrel of the cannon or gun.

Gunpowder has till recently been exclusively employed for this purpose, but gun-cotton bids fair to take its place. They are somewhat similar in their chemical characters, although very differently constituted and manufactured. Gunpowder is made by intimately mixing fine charcoal, sulphur, and nitre, by suitable machinery. The mixture is made into a paste, and then pressed into a thick cake. When it has been dried, it is broken up, powdered, sifted, and corned or grained, in which condition it becomes the powder used in guns and cannons, although it is prepared somewhat differently, according to the purpose for which it is used.

Gun-cotton is prepared by soaking the best carded cotton (see page 15) in strong nitric and sulphuric acids. It is then squeezed, and afterwards washed in water, until every trace of acid is removed, and after drying, may be employed in place of powder. It is sometimes preferred when twisted, because then it fires off less suddenly. Amongst its advantages are, that it does not dirty or render foul the gun in which it is used; produces no smoke; and, if wetted, may be dried, and used with as much effect as when first made, whilst gunpowder is completely spoiled if it becomes wetted.

The manufacture of shot we have already described under a separate head (see page 166), as we have also that of shells, &c., at that page; and our young readers will now expect a detailed account of the mode of making guns, pistols, &c., as pursued at Birmingham and many other places in this and foreign countries. We may mention that Liége, in Belgium, has long been noted for its gun manufacture.

The three chief parts of a gun are the "barrel," which holds the powder and shot—usually called the charge; the "trigger," by which the powder is ignited; and the "stock," to which all the other parts are attached. Formerly the charge was set fire to by means of a piece of flint called a gun-flint, which, acted on by a spring, struck a piece of steel, near which some loose powder was placed. The latter communicated with the charge in the barrel, and so the gun was discharged. Now the percussion cap is used. It consists of a little copper cap, containing some explosive substance, which, on being struck by the hammer, explodes, and communicates, by means of a little tube called a "nipple," on which it fits, with the charge, and so sets fire to it. By this ingenious plan the gun need never miss fire, and hence it is a great improvement on the old one, which often failed when the rain wetted the loose powder, or the wind blew it out of the pan.

The stock of a gun is simply a piece of wood, generally walnut, so shaped as that one end may conveniently rest on the man's shoulder, whilst the other has attached to it the barrel and trigger of the gun. The trigger consists of a spring acting on a lever, which ends with what is called the hammer. And this spring is so arranged, by means of a notched piece of metal, that the hammer may lay close on the nipple or cap, at some little distance from it, when it is said to be at "half-cock," or at a still greater distance, as at full cock. When in this condition, the little handle, which forms the real trigger, if pulled, releases the spring, allowing the hammer to fall with great force on the cap, by which the latter is caused to explode.

The barrel is by far the most important part of the gun; and here we must explain the difference between a smooth and rifled barrel. The former is turned, by means of a tool and lathe, into a complete circular form, all the way through from the muzzle or mouth of the tube to its closed end or breech, into which the nipple on which the cap fits is inserted. The rifled barrel, on the contrary, has a narrow spiral or screw-like line cut down the barrel, the object of which is that the ball shall not only fit tight in every part of the barrel, as it is fired out, but that also it may revolve round its axis once as it proceeds from the powder to the muzzle.

The result thus gained is that, whilst in the smooth-bored gun the ball never fits tightly, but "wobbles" in its progress through the barrel, causes a loss of powder on all its sides, and, moreover, has great "windage"—a result of this last defect—the rifle ball fits tightly, has no windage, and hence *all* the force of the powder is expended on it, and it progresses through the air in an almost straight line to the object at which it is fired.

It is to this rifling that the perfection of modern gunnery is due; and our young readers may guess the extent of this, when we say that a good rifleman will not make an error of an inch in firing at an object at 600 to 1,000 yards distance; whilst with a smooth-barrel gun the shot would fly yards right or left of the object, and hence is absolutely useless at such a distance.

There are many other metals the manufacture of which we might have described here; and some of which we shall have to speak of hereafter in connection with other trades. But we have chosen such as we think will be most interesting to our young friends; for those mentioned are connected, more or less, with our daily life in some way or another.

There is one metal, however, which we may but allude to—it is aluminum, or aluminium,—for this connects the present with the following chapter. This singular metal is contained in common clay, of which pottery, &c., is made. It is shining and white as silver, and has been made up into many useful and ornamental articles. One of its advantages is that it is very light; hence a little of it goes a great way. Alum, the emerald and other gems, the bricks of our houses, our tea-cups and other pottery, all contain it; and it is one of the latest wonders which chemistry has afforded us.

CHAPTER IV.

GLASS AND POTTERY MANUFACTURES.

We have included in this chapter two distinct branches of trade, which are divided into many others, because the material employed in each is nearly identical. It may surprise our young friends when we state that the transparent glass which we use for our windows, looking-glasses, wine and other bottles, &c., and the pots, tea-cups, and porcelain articles of all kinds, are all produced respectively from the sand and clay which form the dust and dirt of our streets. It is true that the ordinary sand and clay are only employed for common articles, and that the finer sorts are selected for manufacturing the better class of glass and pottery; still, in a chemical point of view, the material is the same, the degree of purity alone being the difference.

There is, however, an essential difference in treating the materials used in each manufacture. In the case of glass, the sand, &c., are melted; whilst in making pottery, the clay, &c., are only hardened or baked by the action of heat. Indeed, if the potter raise the heat too high, a portion of the material becomes fused or melted, and the article is spoiled. By modifying this, however, he manages to "glaze," that is, to cover, the outside of the articles with a kind of glass—a process which we shall explain at a future page.

The various articles manufactured of glass and porcelain are devoted to similar uses, especially when the vessels are intended to hold liquids. From this, and the reasons we have already assigned, it will be evident that the two classes of manufacture may most properly be considered together; and we shall accordingly commence with that of glass—first giving an account of the method of making the material, and then explaining the different branches into which the art of working in glass is divided. Our young friends should visit a glasshouse, or pottery, and, if resident in London, they will find no difficulty of obtaining admission to either, if they apply on proper days in the week. We shall first visit

THE GLASSHOUSE.

On entering a glasshouse we notice in the centre a large furnace in the shape of a dome-covered circle, and on walking round this, we see openings leading to a large vessel or crucible, filled with glass, which is so hot as to give a most brilliant light, almost dazzling our eyes.

In the language of the glasshouse, the fluid in this vessel is called the "metal." It is made by casting various proportions of sand, barilla (a substance obtained by burning sea-weed, and containing much soda), a little oxide of, or red lead, and other materials in minute quantity and of less importance. When the mixture is heated very strongly, the soda acts on the sand, and melts with it, the lead being added to make the "metal" soft and easily worked. Glass made with soda is much sooner melted than that made with potass or pearl ash. The latter kind is that often known as Bohemian, whilst the former is almost exclusively made in this country, and is far more readily blown, cut, &c., than any other kind.

The proportions of the materials, and their choice, depend on the article to be made—the coarser sort being used for wine and pickle bottles, whilst the finest material is employed in making plate glass, glass vessels for drinking, and other purposes. A little of the metal manganese is used to correct the colour which a small portion of iron would give to glass, and to insure its purity and whiteness. The iron is accidentally derived from the sand used, and much deteriorates the value of the glass if not removed.

When the materials are all placed in the crucible, the heat is gradually raised in the furnace, which is fed with small coals for the sake of economy, and produces an immense quantity of black smoke. Hence a glasshouse is almost always built either in a low neighbourhood or at a distance from other houses, for it is generally a great nuisance to all surrounding it. The materials become gradually fused or melted, and, combining together, form a thick fluid having the consistence of treacle. Many precautions are required to insure their proper mixture, and the fluidity of the "metal;" but such matters are too practical and technical to be worthy the notice of our young friends.

When the "metal," or fluid glass, is thus ready, it can be used, according to its quality, for blowing, moulding, window and plate glass, &c. We shall therefore consider these separately, as far as they can be so dealt with.

THE GLASS-BLOWER.

Glass-blowing is one of those operations that depend entirely on the skill of the workman. His tools are of the simplest kind, and consist of a long iron tube, through which he blows air into the glass, a flat metal table, on which he rolls or shapes the vessel, an iron rod, &c.

He dips one end of the tube into the melted "metal," and, withdrawing a portion of it, blows into the melted or soft mass at the end, turning the tube or blower round and round with his hands. A circular, hollow, or globe-like form is thus given to the glass. As soon as this gets cooled he introduces it into the top of the crucible, so that it may again become red-hot and soft. On withdrawing it, he again blows it, and afterwards rolls it on the flat table, by which he converts the globe into the shape of a cylinder. By such processes, and by aid of tongs, he gradually gives the vessel its proper shape; and in our description we have supposed that he has been making a common glass bottle. When it is complete in shape and form, the neck portion is that attached to the iron tube or blower, whilst the under end, or bottom of the bottle, is that farthest from the end of the blower. He easily removes the vessel from the blower by touching the glass at the neck with an iron rod wetted with water. This cracks the hot glass, and the bottle is removed.

Such is a general description of the mode of blowing glass. In making other articles the process is modified; and it must be borne in mind that when glass is red-hot it may be moulded, bent, or blown into any form, for it is far softer than wax, and is as pliable as possible. Thus feet are readily attached to the bell of wine glasses, handles to jugs, &c., the body of which has been already blown.

Of late years, "moulding" has been largely followed in place of "blowing." An iron mould is made, somewhat after the manner of the sand moulds described under the head of the "Founder," at page 141, and the glass is either forced or poured into these. The cheap uncut tumblers, scent bottles, sugar basins, glass jugs, water and wine bottles, &c., are now made in this manner, and if properly *annealed* they last a long time for ordinary use.

We must here explain what the term *annealing* means. We have already done so when speaking of manufactures in metal (see page 148), but must be rather more extended in our remarks in reference to glass and pottery articles.

If a piece of melted glass be dropped into cold water, it will cool, and appear like ordinary glass, but if it be touched with a little sand, or a file, it instantly flies to pieces. In a similar manner, a tumbler, or other glass vessel that has been rapidly cooled after having been made, will, if hot water be poured into it, fly into pieces. These effects arise from the fact that the inner and outer parts expand unequally; and the only method to prevent it is to heat gradually the glass to nearly its melting point, and then to allow it to cool very slowly indeed. This is the process and art of annealing. The glass vessels, after leaving the hands of the blower or moulder, are placed in a kiln or oven, and heated. The door of the kiln or annealing oven is then closed, and the vessels are allowed to cool very gradually. They are thus completely *annealed*, and readily stand sudden changes of temperature, without being liable to break. It is owing to common tumblers, &c., being unannealed that they so often break on being first used in our houses.

Window glass, that is, the thin crown, is made by blowing, but during the process the workman, instead of making a hollow vessel, dexterously casts or throws the glass in such a manner on to a suitable table, that it assumes a circular, thin, sheet-like form. The thick round mark found in the centre of a large sheet of crown or common window glass is the place where the blower was introduced, and it is called the punty mark.

Plate glass is now manufactured by machinery. The "metal" is poured out on to a long table, and rolled to flatten it. It is subsequently polished by machinery, and its surface carefully picked over to remove defects. There are other methods of making glass in the sheet form, such as is used in windows, for tiles, &c.; but our space forbids further details. In all cases the "metal" is cast, usually moulded, as in bent tiles for roofing purposes, and thus the glass tiles for lighting railway stations, warehouses, cellars, &c., are produced in any desired form.

Glass is exceedingly ductile when heated to a red heat, and can hence be drawn out into a fine thread. This is generally done by fixing one end of a piece of glass tubing to a wheel, whilst the other is held in the hand of the workman. A gas or other flame is held between the two until the glass is nearly melted. The wheel is then turned round rapidly, and a continuous fine thread of glass may be produced as long as any of the tubing is supplied. By using glass of various colours beautiful effects may be obtained, for, of course, the thread is of the same colour as that of the tubing from which it is made. Many glass ornaments are thus made, especially the tails of birds, &c. We have seen "cloth" made of this material; it looks very beautiful, but has a singular effect on the wearer, for the edges, when broken, will prick the skin of the hand, &c., if exposed to it. Hence ladies thus dressed might find themselves extremely uncomfortable in such articles of attire.

The bending of glass is easily effected by heating it, and then it may be moulded into any form. Glass tubes, &c., are thus bent into convenient forms for the use of the scientific man. Glass frames for windows and show-cases are made by heating them, and subsequently employing compressed air. This being equally elastic in every direction makes an even curve in the glass where heated, in a manner which would be impossible if the glass were bent by the pressure of a solid substance. Glass shades, such as are used to cover clocks, birds, and other objects used as ornaments, are produced by the ordinary method of blowing: a special dexterity, however, is required, and this accordingly makes it a separate branch of business.

Glass of all kinds is cut or divided by means of a small fragment of the diamond. The crystal is so set in a handle that at one edge it may expose the sharpest point. On drawing this edge down a piece of glass a slight scratch only is made, but this is quite sufficient to guide the fracture in that line only. Hence, when the piece of glass is slightly pressed on each side, it breaks on the scratch alone, and at no other part.

Our young friends may divide a bottle, cut off its neck, &c., by drawing over any part an iron rod made red-hot, and then passing over the same place a cold one wetted with water. A piece of string wetted with turpentine, and tied round the part to be broken, if set fire to, will answer the same purpose. Glass may easily be drilled by means of the common fiddle drill used by watchmakers, if the place be kept wetted with oil of turpentine at the part through which the drill is to make a hole; and similarly, a hard file and turpentine may be used to cut off the neck of a bottle.

Glass vessels when broken, or glass and metal, may be united by coating the surface with a solution of shell-lac in spirits of wine. This is what is called glass cement, and is sold for these purposes in the shops. We next speak of the trade of

THE GLASS-CUTTER AND GRINDER.

Glass is readily cut by means of any rough surface rubbed against it. Thus a file will easily divide any glass vessel, after the outer polished surface is removed. The implements of trade of the glass-cutter partake in their use with that of the file. He uses a lathe on which is fixed a wheel: the edge of this is kept covered with emery or hard sand. The wheel is made to revolve rapidly in water by means of a treadle worked by the foot. The cutter then presses the surface of the glass vessel against the edge of the wheel, when it is instantly cut to any depth he pleases, and it assumes the appearance of ground glass. By turning or moving the vessel in different directions, any pattern may thus be cut on the glass, as, for example, flowers, leaves, &c., and thus it becomes beautifully ornamented. Some parts require polishing, as, for instance, the outsides of tumblers, bottles, wine glasses, &c. This is done after they have been ground into the required shape, by using another wheel, covered with putty-powder, and the rough, ground surface is pressed against the wheel, when the glass soon becomes as beautifully polished as that portion which had never been ground.

Some beautiful devices are also produced on glass by means of an acid obtained from fluor spar. It is called hydrofluoric acid, and is the liquid used to produce those beautiful patterns which ornament window glass, used in place of blinds or screens, in our parlour, shop, and other windows. We shall describe the process, by instructing our young friends how to carry it out themselves; and by following our instructions with a little care, they may easily obtain some very pretty results on a piece of common window glass. The process is as follows:—

Bend a piece of *sheet lead* into the shape of a little square tray, so that its edges may be raised about half an inch higher than the bottom. This will form the vessel for making the acid, and *lead* only must be used, because no other common metal will resist its action.

Take a piece of clean window glass a little larger

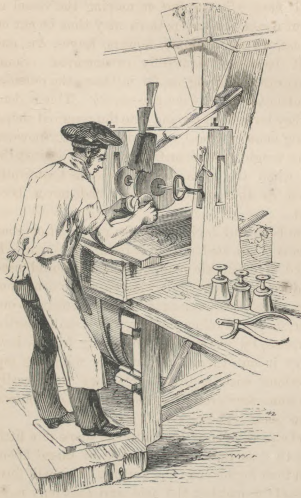


PLATE 14.—GLASS CUTTING MACHINE, p. 204.

every way than the tray, and coat it with white wax on both sides, by pouring the latter over it in a melted state. The wax may be easily melted in a tea-cup; and when the glass is covered, it should be held at one corner, so that all unnecessary wax may be drained off.

The waxed glass is to be left until quite cold. Then trace upon it, on one side, any pattern you please, by means of a sharp wire or a thick needle. Your name, for example, may be thus traced, and care must be taken that all the wax is removed in the tracing.

Next put a few pieces of fluor spar, in coarse powder, into the lead tray, and pour a little strong sulphuric acid on it. Place the *traced* side of the glass, face downwards, over the spar and acid, and hold the tray with its bottom over a candle, so as to warm the acid, but take care not to hold it so long as to melt the wax.

Set the tray aside, and after an hour or so remove the glass, and take off the wax by heating it. The pattern, already traced through the wax, will be found bit into the glass, and permanently fixed on it. It is by precisely such means, only with more elegant patterns, that glass screens are produced.

Ground glass globes for lamps, &c., are produced by rubbing the glass with emery and water, and this, owing to their shape, must be done by hand.

Optical glasses, lenses for spectacles, telescopes, &c., are ground in a lathe, a hollow mould being used, having a concave surface corresponding to the convex or raised surface intended to be produced on the glass. The mould is lined with resin or pitch, and covered with emery, being also kept wetted. If a concave lens is required, a convex mould must be used. The operation is precisely similar in all other respects to that we have described in ordinary cutting and polishing.

THE GLASS-STAINER.

Glass-staining, and stained glass, often so called, must be carefully distinguished, because the latter term is often applied to glass that is simply coloured by painting it with transparent colours. Glass-staining proper consists in first painting the surface of the glass with a substance which, on being afterwards burnt into the glass by a red heat, renders the colour completely permanent, and, in fact, makes the colour resident in the glass itself, from which, therefore, it cannot be afterwards removed.

A suitable piece of glass being chosen, the colour is laid evenly on its surface; and the materials used are oxides or "rusts" of certain metals, the chief of which are the following:—

Oxides of Iron produce a green or brown colour.
" Copper produce a red colour.
" Cobalt produce a blue colour.
" Chromium produce a green colour.
" Uranium produce a green colour.
" Tin produce a dead-white colour.

By choosing one of these substances, and placing it on the glass, the first step is taken. The glass is then placed on an earthenware stand, called a "muffle," and introduced into a furnace. It is to be heated red-hot, and gradually the colour is absorbed into the glass, which retains its transparency despite the change of colour.

By such means glass used for making ornamental windows in churches, &c., is produced. Many beautiful objects, however, are produced by coating white or coloured glass with other colours. The latter are then ground away, until the inner colour is shown, and by such means the ornamental vases, flower-holders, &c., are made—any amount or variety of colour being obtained, according to the number of coats or the depth to which they are cut. The cutting is carried on in the manner already described in the preceding article.

Glass-staining requires great care and judgment, all depending for its success on the skill and practised eye of the workman. The trade is much followed in this country; but many places on the Continent, especially Munich, rank high for excellency of workmanship.

Pastes, or artificial gems, are a kind of glass; but of these we shall speak when we refer to jewellery.

THE LOOKING-GLASS SILVERER.

In our younger days we were once asked the question, being thoughtless, "Why are you not like a looking-glass?" On giving up the question, our friend said, "Because you speak without reflecting, whilst the glass reflects without speaking." We name this as a hint to *some* of our young readers, and now proceed to explain why a looking-glass reflects, and how that effect is produced.

Rough unpolished surfaces cannot reflect or send back rays of light to our eye, because they either disperse or absorb the light; but most polished surfaces return or reflect to our eyes a great proportion of light; hence a polished surface must be used to make a reflecting one.

In ancient times, metals—as, for example, gold, silver, copper, &c.—were polished to serve as "looking-glasses," and it was such as these that the Grecian and Roman ladies used for arranging their toilet. The glass was very dear—in fact, cut glass was more valuable than gold. But in our days it is a very cheap material; and, being capable of receiving a highly polished surface, is the best article that we can employ for the manufacture of looking-glasses.

The process depends on coating the back of the glass with a metal having also a polished surface; and as no solid metal is sufficiently pliable to adhere perfectly to a flat surface by itself, the aid of mercury is called in, which, uniting with tin, to form an amalgam or semi-fluid, can be pressed close to the glass surface, and will then completely and permanently adhere to it.

"Silvering," then, consists in coating one side of a piece of glass of any form with an amalgam. We may here mention, however, that no silver whatever is used in the process. There is a plan by which a solution of silver mixed with various essential oils, poured into a globe or bottle, and exposed to daylight, will completely and really silver the glass internally. But it is rarely used, except for such purposes as we have just named. The ordinary mode of "silvering" is pursued in the following manner, which we shall describe in an experimental form, so that our young friends may become practically acquainted with it, and try it for themselves:—

Procure a piece of good plate glass, quite free from specks. Wash and dry it carefully, so as to make it perfectly clean, and heat it gently, allowing it afterwards to become quite cool before using it.

Now place over it a piece of tinfoil, which may be procured, together with the mercury or quicksilver, at any chemist's shop. Spread the foil perfectly straight, by pressing it with a soft cloth, so as to remove all the creases and make it quite level. Pour upon it a little of the mercury, and then, by means of a hare's or rabbit's foot (a camel-hair brush will do), spread the mercury so that it may touch every part of the tinfoil.

When this is done, place on the foil a sheet of note paper, on this a piece of thick card-board or card, and on the whole a weight of ten pounds or so, in order that the mercury, &c., may be closely pressed on the glass, and any superfluous quantity removed. The whole should be arranged in a slightly slanting position, by which the mercury that is useless can flow off. It should be allowed to run into a plate, to prevent its being wasted.

In a day or two's time take off the weight, card, and paper; and on holding the uncoated side to the face, it will afford a complete reflection of it, owing to the reflecting power of the metal coat at the back. In fact, a complete "looking-glass" will have been produced.

Of course, on the large scale, the process is carried on in a more business-like manner; but the details are only of value to the practical man, and our young readers will have learned all that is necessary by the experiment we have suggested.

Silvered glass is used for many purposes besides that of making looking-glasses, and our young friends will easily call to mind many of these on "reflection."

THE POTTER.

We have devoted so many pages in describing the different trades depending on the manufacture of glass, that we must be very brief in dealing with that of the potter. His materials and implements are well known. The former consist of various kinds of clay, which produce us a great variety of pottery. The coarse or inferior kinds, such as may be obtained in the clay-fields surrounding London, and other of our large towns, are used to make tiles, red pottery, garden pots, and other coarse articles. For such objects as cups and saucers, tea-pots, &c., a much finer and whiter kind of clay is used, and this is mixed with flints, which are first burned and then reduced to a fine powder. The best and finest material is a kind of clay called *kaolin*, that is found in some parts of England, but abounds also in China; and possibly, from the best class of pottery being produced in that country, the term "China" or "Chinaware" has been applied to the superior kinds of crockeryware used in our houses.

Pottery, like many other trades we have described, has its favourite localities. In Lambeth, near London, there is a large trade carried on with the coarser kinds; whilst in Staffordshire, at the "Potteries," our chief supply of the better kind is derived. We may here mention that the excellency of English pottery is due in a great measure to the energy and taste of the late Mr. Wedgwood, who was amongst the first not only to improve the material, but also to show taste in the choice of designs painted on the various objects produced by the potter. In fact, the character of English pottery in both these respects has been acquired almost entirely since the beginning of this century.

Our young friends will be surprised when we state that the clay which the potter uses contains a metal that is now turned to a great variety of purposes. This metal is called *aluminium*. It is exceedingly light, keeps a good polish, and has many other valuable qualities. It may also be interesting if we state that the emerald, many other precious stones, alum, &c., all contain the same earth as common and best pottery clay. It is called *alumina*, and when pure, is very white; when nearly in this state it is the chief constituent of *kaolin*, which we have already named.

So far for the material of the potter: we must now speak of the implements or machinery of his trade.

In the earliest histories we find mention of the potter's wheel, as, for example, in many parts of the Old Testament, and in many other ancient works. Strange to say, the wheel now used by the potter scarcely, if at all, varies from that used 3,000 years ago; and our modern instrument is almost exactly represented in the paintings or sculpture on old walls, &c., in Egypt and Asia Minor. It consists of a large wheel connected, by means of a strap or band, with a smaller one; so that the latter may be turned much faster than the former, when that is worked by the hand or foot. Above, and fixed to the smaller wheel, is a little table, which, of course, turns round as the wheel rotates; and on this table the clay is placed, to be moulded into any desired form.

The clay is prepared by grinding it under large stone wheels with a little water. This is done until it is very fine, soft, and pliant, when it has the consistence or stiffness of soft putty, in which state it is fit for the potter's use.

It would be impossible for us to describe the different methods which the potter follows in making the various articles of his trade. We shall therefore confine ourselves to explaining the manufacture of a ginger beer or blacking bottle, and its conversion into a jug; and as we have often made both for our amusement, we do not doubt but that we shall succeed in giving our young readers an idea of the processes generally followed throughout the potter's trade; for such vary but slightly from those we shall describe, and depend on the form or shape alone.

The clay, in sufficient quantities to make the bottle, is placed on the table of the "wheel," which is then made to turn rapidly. As it does this the clay has a tendency to fly outwards, but is restrained by the potter's hand, and shaped by forcing it upwards until it assumes the form of a cone, having a little more than the height of the intended bottle. A piece of flat iron is now introduced into the centre of the cone, which is still kept revolving, and gradually the inside is scooped out, and the whole is turned into a shape exactly resembling the pots in which jellies or preserves are kept. In fact, such pots are thus made. But to put on the top of the bottle, a flat piece of clay is added, in a somewhat similar way as a paste is made and put on to the fruit in a pie, and the edges are scraped and turned until they and the outside are quite even. The neck is then added by putting on another piece, and the hole in the neck and the rim are also formed by dexterously using a piece of flat iron, applying it in and outside as the bottle is caused to revolve. The latter is now ready for the next process, which is that of baking.

If a jug be required, of course the neck and top of the bottle are useless, and the body of the jug is formed by moulding the soft clay by the hand, as the material assumes the form of the pot previously described. The handle is made by rolling a piece of the clay into the form of a rod, and this piece is then taken up and fixed to the sides of the jug by the fingers of the potter; it is then pressed thereon, when it adheres tightly, and if sufficiently stiff, holds its shape without any risk of falling. We may here name that the potter constantly "tempers" his clay; that is, if too moist, he mixes it with some that is drier; or, if too dry, he wets it with water. By such means, and long practice, the most delicate piece of pottery is fashioned, including devices of flowers, handles, &c. In respect only to perfection of workmanship, dependent on the skill of the potter, combined with purity of materials, does the most beautiful vase differ from the ordinary pot. No machinery, but only the hand of man, aided by a few pieces of flat iron or wire, being used.

After the clay has been thus formed into the requisite shape it has to be dried before being baked, turned until they and the outside are quite even. The neck is then added by putting on another piece, and the hole in the neck and the rim are also formed by dexterously using a piece of flat iron, applying it in and outside as the bottle is caused to revolve. The latter is now ready for the next process, which is that of baking.

If a jug be required, of course the neck and top of the bottle are made, and the body of the jug is formed by smoothing the wet clay by the hand as the material assumes the form of the one previously described. The handle is made by rolling a piece of the clay into the form of a rod, and this piece is then gently and well pressed to the side of the jug by the finger of the potter. It is then pressed, however, whilst it adheres tightly, and if sufficiently stiff, holds its shape without any risk of falling. We may here state that the potter invariably "tempers" his clay, that is, if he uses it, he mixes it with some that is [illegible], if the clay be wet, it [illegible] with water, by such means and [illegible] the more delicate piece of pottery is fashioned, including the vases of flowers, lamps, &c. In respect only to perfection of workmanship, dependent on the skill of the potter, combined with quality of materials, some of the most beautiful vases [illegible] the ordinary potter's wheel, but only the hand of man, aided by a few pieces of flat iron or wire being used.

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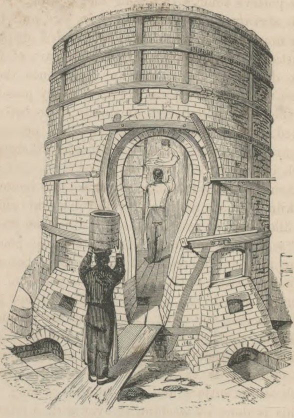


PLATE 15.—POTTERY KILN, p. 215.

and this is one of the most important departments of the potter's trade. In drying and baking, every article *shrinks at least one-third in size*, and the potter must make allowance for this in first shaping the article. Now, unfortunately, each part of the object does not shrink equally, and hence there is great risk run in drying; for with every possible care, the object will dry so unequally as to become crooked, and therefore useless. In these processes "seggars" are used. They consist of earthenware vessels in which the pottery is placed.

When the article is sufficiently dried, it is removed to a kiln. This is really a very tall and wide chimney, filled with shelves made of fire-brick, on which the "seggars" containing the pottery are placed. A fire is then lighted, and the pottery becomes gradually heated, until red-hot. The whole of the water is thus driven off, and the clay at last gets hard, tenacious, and solid. The vessels are gradually cooled by putting out the fire of the kiln, and leaving them there until the walls are quite cold. The crockery is then removed, when it appears rough on the surface, and now requires glazing.

This is done by washing it over with a mixture of fine clay, common salt, borax, and other materials, which, on being exposed to heat, do not become solid, but melt into a kind of glass. The vessels thus washed are then placed in a kiln, and heated until this earthy wash is completely fused. On being cooled, the vessels are then quite water-tight, and in just the same condition as our tea-cups, &c. Before glazing, they are porous, just like the common garden pot, in which condition they would become useless for the ordinary uses to which they are applied. The glaze, therefore, is not only ornamental but essential for the perfection of the article. Common pottery, as bread-pans, &c., are only glazed inside, because they are not used to hold liquids. The reason that many such articles break or become useless is frequently owing to the imperfect manner in which they are glazed. A large quantity of these, as sold in the streets, are, in fact, waste or spoiled articles, which the potter dare not sell to his ordinary customers.

The best kind of chinaware is produced in Dresden, Meissen, and other towns in Germany. In France, the manufacture at Sévres is of the highest kind, and fetches a great price. Worcester is noted for some fine kinds of best ware; and many of the English manufacturers rival their foreign brethren.

We have as yet only described the manufacture of plain or white pottery; but we must now explain how the patterns are given to plates, cups, vases, &c.

The design is first sketched on paper of the shape of the article, and this is then transferred to the ware, the colours being applied on the unglazed surface by means of a camel-hair brush. The colours consist of mineral substances, such as cobalt, copper, iron, and other oxides, rusts, or salts. They are burned in by heat, and afterwards the object is glazed in the manner already described. The beauty of the pattern depends on the taste and skill of the designer, the purity of the colouring materials, and the care observed in burning them in, so that they do not "run," that is, spread out beyond their proper place in the design; and it is in these departments of the potter's trade that the foreign workman often excels.

We have already said that the form of all kinds of pottery simply results from the dexterous use of the hand and simple tools of the potter; and this holds good in every article, whether it be plates, saucers, &c., which are flat, or jugs, vases, &c., that are hollow, and of various heights. The body of the vessel is first made, and the ornaments, cut or fashioned out of a piece of clay, are then fixed or stuck to it before drying and baking. Objects of sculpture require great art in fashioning, drying, and baking; but when well done they almost rival the art of the sculptor in marble. Splendid specimens of this kind were exhibited in 1851 and 1862 at the Great Exhibition in London, under the name of Parian ware.

Many terms are used in the pottery trade besides those we have named, such as "Delph," "Crockery," "Porcelain," "Ceramic Ware," &c., each being intended to designate the quality of the article, and to distinguish those recently brought out as novelties; but, as we have already stated, the principles and processes of manufacture are nearly the same in all.

Before concluding this description of the trade of the potter, we may mention that our young friends resident in or near London may easily obtain admission to any of the potteries at Lambeth, on certain days of the week, and thus gain an insight into the processes followed in the lower kinds of the manufacture.

It may amuse, and be useful to many of our readers, if we mention a curious method of joining a piece of chinaware that has been broken. If a broken tea-cup, for example, be tied so that all the pieces shall join accurately together, and the whole be put into a saucepan filled with good milk, kept boiling for a few hours, the lime in the milk will be gradually deposited in the cracks. On taking off the tape, as soon as the cup is cooled, it will be found that each part has been perfectly re-joined, and so firmly that it will be impossible to break it again at the same place. In fact, the cup will be completely mended, and as good as new. By similar means any other china article may be repaired; and we accordingly recommend it especially to the ladies of our households, whose tempers are often sorely tried by the carelessness of servants in the breaking of tea-cups, saucers, and other such articles of domestic use.

CHAPTER V.

TRADES CONNECTED WITH GUTTA PERCHA, INDIA RUBBER, ETC.

We have hitherto been able to give a separate name to each trade connected with the materials used in so many ways by man. But those two valuable substances, gutta percha (which our young friends should pronounce as *pert-sha*) and india rubber, whilst applied in so many ways, have not given rise to so great a variety of separate trades; their use has rather been united with or added to those in which other materials are used, and for which they have become substitutes. Thus gutta percha is used both with and in place of leather, whilst india rubber is employed in addition to, or instead of, woollen and other woven articles. We shall treat on the trades of these substances together, for they are so much alike both in respect to their properties, manufacture, and varied uses.

Gutta percha was first brought into notice by Dr. Montgomerie in 1843, although it had been known in museums simply as a curiosity for some time previously. It is chiefly obtained from a plant called *Isonandra Gutta* by botanists; and the Malay Islands are our chief source of this valuable gum.

It is imported into this country in the form of clay-coloured cakes, and in the tree exists as a kind of milky juice between the wood and the bark, from which it is withdrawn by means of holes. On being exposed to the air, the juice completely hardens; but, as all our young friends know, it is readily softened by heat—one of its most valuable and useful properties, and on which its adaptation entirely depends.

As thus received it requires cleansing from dirt of all kinds, which becomes accidentally mixed with it, or may be added to fraudulently increase its weight. For this purpose the raw gutta percha is sliced into thin shavings, and well washed in hot water. When sufficiently cleansed, the thin shreds are kneaded by machinery into cakes, and in this state it is transferred to rollers heated by steam. On being passed between these it is gradually converted into a sheet of any desired thickness, varying from half an inch to that of ordinary writing paper.

As we have already mentioned, the gum may be converted into any shape by being heated; hence the great variety of uses to which it is applied. To enumerate these would be scarcely possible, but some we can at all events name. It has been largely used to cover submarine wire for telegraph cables, because it is a non-conductor of electricity, or, in other words, does not allow the electricity to leave the wire conveying it. Being a bad conductor of heat (see page 2), it is very valuable as a material for the soles of shoes—a purpose to which it has been very largely applied; and also, for the same reason, it is an excellent material for water-pipes, inasmuch as that liquid will scarcely, if ever, freeze in our climate when conveyed in gutta percha pipes.

From its being readily moulded into any form, electrotypers largely use it; and picture frames, ornamental mouldings, inkstands, &c., are made from it. But it will be unnecessary for us to name more of its uses, as all of our young readers will readily think of many of them. There is one advantage it possesses, which is that, after having been once manufactured, it does not become the "worse for wear;" for whatever is left of it may be readily converted into other uses and purposes by simple heating, rolling, and moulding.

India rubber has been long known, but, like gutta percha, its most valuable qualities have been only discovered of late years. When we were very young, the only use to which we remember it to have been applied was that of rubbing out pencil marks. It then became used to make waterproof clothing, and subsequently, as we shall see, its uses have been very numerous.

Caoutchouc, or india rubber, is a milky juice found in many trees and plants, and even our common lettuce, &c., contains it. But its chief source as a commercial article is from the *Siphonia Brasiliensis* as grown in Brazil, and sent to us from Para, in that country. The *Ficus elastica*, a tree belonging to the mulberry tribe, also largely yields it, affording nearly a third of its weight of this valuable gum.

As obtained from the trees, the juice has a white colour. When obtained it is moulded over a lump of clay in the shape of a pear, and being dried over a black smoky fire, it obtains the dark colour commonly noticed as we see it here. But it is also imported in other forms; and we may here tell our young friends of a bit of fun which we had with a gentleman who rather prided himself on carving. We had a piece, exactly resembling a piece of a flitch of bacon, warmed and served up in place of that article, and so like was it, that our friend attempted to cut it at table. He, however, soon found out that india rubber is much tougher than the flesh of the pig, and created much laughter at his useless endeavours to divide it into slices.

Before manufacturing, india rubber is cleansed in a manner similar to that we have described when speaking of the preparation of gutta percha. It is then kneaded in a "masticator," which consists of an iron chest heated by steam, and in which spiked rollers revolve. It can then be converted into sheets by rolling. If required for making into elastic web, as used for braces, garters, &c., it is cut into thin shreds by means of saws, and is then covered with silk or cotton thread. If made into tubes, long ribbons are cut, and these are twisted over metal tubes, when the clean cut edges readily adhere together. Thus tubes or pipes for conveying gas and liquids are made.

But india rubber, in its ordinary state, whilst very elastic, has not, like gutta percha, the power of completely returning to its old form after having been much heated or long stretched. If, however, it be heated with sulphur to a temperature of 800° of our thermometer, it acquires new properties, and becomes what is called *vulcanized india rubber*. In this state it is much harder and more durable; it is unaffected by chemicals, oils, &c.; and in many other respects is greatly improved for general use. It may also be mixed with other substances. With magnesia, it affords a material which is so solid that combs, knife-handles, inkstands, and many other useful articles, ordinarily made of wood or bone, are produced from it.

For many reasons, india rubber is preferred for covering submarine cables; and in this use it has many advantages over gutta percha, as it can be made perfectly water-tight, and entirely free from holes; whilst being very elastic, it is not liable to be broken if bent or stretched. It is also very light, and therefore does not add much to the weight of the cable.

One of its chief uses is that of making waterproof cloth. For this purpose the india rubber is dissolved in oil of turpentine, by which it forms a thin paste. When this is spread between two sheets of cotton or other cloth, and pressed by heavy rollers, it affords the waterproof cloth used for clothing, sheets to cover waggons, and for other purposes in which a watertight covering is desirable. This use is now of great importance, and, in consequence, the consumption of india rubber has enormously increased of late years.

"Kamptulicon" is a kind of floor-cloth made by working ground cork with india rubber in the "masticator" already mentioned. The mass is then rolled out into sheets, and has the advantage of affording a covering for floors that deadens sound, prevents cold feet, and wears a long time. This cloth can be printed on in a manner similar to that followed with floor-cloth, for which it forms an excellent substitute.

Vulcanized india rubber has many uses besides those we have named. It is used as washers or packing for joints in steam engines and boilers; valves for pumps, buffers for railway carriages, covers for wheels, to prevent their noise both on rail and common roads. It is also made into door mats door springs, life-boats, straps for driving machinery, goloshes, overshoes, braces and garters, and articles more or less in daily use in most houses of our own and all civilized lands.

If heated with tar and sulphur, india rubber affords a solid, hard substance, resembling jet; and from this combs, pencil-cases, bracelets, &c., are made. But, as in the case of gutta percha, we must refrain from attempting to name all the varied uses to which it is applicable.

Very recently a substance called *Linoleum* has been proposed as a substitute for both india rubber and gutta percha. It is produced by heating linseed oil with substances that have the property of turning it into a kind of rèsin; and in that state it is combined with gums or resins, when it obtains nearly all the properties of india rubber, and can be used in place of that substance. It is much lower in price, and can be made of any degree of hardness.

Our young friends will no doubt have felt much interest in reading our account of the preparation of gutta percha and india rubber, and of the sources whence they are obtained. But a few years ago they were both little better than curiosities in our museums. Now they occupy thousands in their manufacture, and are applied to the most important purposes of every possible variety. They perhaps afford the most interesting example of any substance procured from the vegetable kingdom in respect to the number and utility of their applications.

With this chapter we conclude our description of the various trades carried on in this country, that form what we may term "staple manufactures"—that is, such as are most necessary for our comfort, and the most extensively pursued in converting "raw material" into useful articles.

Our young readers cannot have failed to notice how numerous are the trades which depend even on one article. Take, for example, that of cotton, in which there are nearly 500,000 persons employed at factories—in number nearly 3,000—in England, Scotland, and Ireland. But besides these, are shopkeepers and their assistants, shippers, sailors, &c., so that perhaps some million persons are more or less dependent on a little plant and its fruit. As with cotton, so we might remark about flax, wool, silk, metals, and other materials we have spoken of.

In the next chapter we shall deal with trades connected with gas, candles, &c.; and afterwards take up such matters as pertain chiefly to the construction of our houses, their furniture, and the different articles used in them for every variety of purpose in daily life. We shall also be speaking of means of conveyance, as ships, railways, carriages, &c.

CHAPTER VI.

TRADES CONNECTED WITH FUEL, GAS, CANDLES, ETC.

In former times the sources of artificial light and heat were very limited. Our forefathers, a few centuries ago, were in fact ignorant of coal, and wood was exclusively used. Indeed, at the present day there are many places in our own land where wood is still largely used; and on the Continent there are towns where coal is rarely employed at all. But there abundance of wood is readily attainable; whilst with us coal is so abundant and wood so scarce, that the use of the latter is very limited, being confined chiefly in England to farm labourers.

Coal is a vegetable substance, converted by heat and moisture, with pressure, into a black solid mass. By means of a microscope, our young friends may readily detect the stems and leaves of ferns and other plants from which coal has been produced; and our coal cellars will often afford very interesting specimens of what are called vegetable fossils. Peat bogs, which afford much of the fuel used in Ireland, often contain at their lowest part a substance exactly resembling coal; and which, indeed, is that substance in an early stage of production.

We have already given a sufficient account of mining in general at page 136, and shall therefore merely remark that our chief supply of coal in England is obtained from Northumberland, Durham, Yorkshire, Lancashire, Staffordshire, and Derbyshire. Other places also afford it, and a very hard quality, called "Anthracite," used for steam boilers, is largely produced in Wales. In Scotland a large tract of country, reaching from Ayrshire to Edinburgh, supplies an immense quantity of coal of varying qualities. The best kind for house use is that obtained from the neighbourhood of Newcastle, &c.; and this is chiefly conveyed to London by ships called "colliers;" whilst coal obtained from Yorkshire, &c., called "Inland," reaches the metropolis by means of railway conveyance. When coal is used for heating our houses, and for cooking, it is generally burned in open fire-places, and more rarely in stoves. The bars of the fire-place or grate allow of the admission of air, and so facilitate the burning or combustion of the coal. The object of poking a fire is precisely similar, for it opens the particles of the coal which have become "caked" together. The chimney "draws" the air through the coals, and so produces an upward draught, which also causes combustion. Hence, when a chimney "smokes," the draught is stopped, and the fire burns dull. A "smoky chimney" is generally caused by its sides being cold; hence if, before lighting a fire, some paper be burned in the grate, the hot air ascending the chimney warms it, and so produces a better draught.

Coke is coal from which all the gas has been driven off by heat. Such as is used in our fire-places is produced from the coal employed in making gas; and of it we shall again speak when describing the gas-house. Coke for use in our locomotive engines is obtained by heating coal in large ovens, and when thus produced it is very hard, affords a great heat, and yet gives off no smoke. The latter contains many valuable substances, which we must describe under the next head of

GAS MAKING AND THE GAS-HOUSE.

WE have already described the domestic uses to which coal is put, that is for warming and cooking purposes; we now proceed to explain how coal produces gas, how the gas is purified, and afterwards conveyed to the houses of the customers of the gas company.

The best coal for making gas is that which contains the largest amount of bituminous (pitch-like) matter, and, strange to say, the chief part or constituent of coal gas is that which forms a proportion of the water we drink. This gas is called "hydrogen," a name derived from the Greek words signifying "producer of water." In every nine pounds of water there is one pound of this gas.

But in coal gas hydrogen is united with charcoal, or carbon; and it is owing to the presence of this solid substance that coal gas gives light. Gas produced from water affords no light when burned, because it contains no solid matter; but if it is allowed to pass through ether and some other liquids it gathers solid charcoal from them, and affords a good light. Indeed this plan has been proposed in place of ordinary gas-making from coals, the gas from water being employed; but, except under special circumstances, it is too expensive.

Gas may also be produced from oil by heating it in a red-hot pipe, and collecting it much after the same plan as coal gas is stored. It owes its light-giving power also to the quantity of charcoal it contains.

We now proceed to explain how coal gas is produced, but shall first suggest a simple experiment by which our young friends may gain an insight into the principles on which the manufacture of gas depends. For this purpose put a few small pieces of coal into the bowl of a common tobacco pipe, and then cover the open part of the bowl with some stiff clay, so that no gas can escape. Place the bowl in a hot fire, and after a short time—as soon as smoke issues from the stem—apply a light to the other end of the stem. The gas will catch fire, and burn as long as it is afforded from the coal. The explanation is very simple. The heat of the fire drives off the water, gas, &c., contained in the bowl of the pipe; and thus common gas—certainly very impure—is obtained. It was by just such an experiment like this that the properties of coal gas were first discovered; and it was so late as the beginning of this century only that coal gas was first applied for lighting purposes.

In the gas-house iron retorts and pipes take the place of our tobacco pipe. The retorts are long vessels made of cast iron, flat at the sides and the bottom, but oval at the top. They are built into large furnaces, and before being used they are nearly filled with coal. When this "charge," as it is called, is put in the mouth, which is the only open part of the retort, it is closed by a flat plate holding a pipe. The end of each pipe is connected with a long one running opposite to the retorts, and called the "hydraulic main." This contains a little water, into which the ends of the retort-pipes dip. As the retorts become red-hot the gas from the coal is driven off, and, passing through the pipe in the lid of each, bubbles up through the water in the main, and passes to a series of pipes exposed to the open air, or constantly kept wetted outside with water. The object of this is to cool the gas before passing into the "purifier."

This apparatus is a closed vessel, containing trays of lime mixed with water. As the gas passes over the lime the impurities it contains are seized by the earth, and so the gas is purified. Many contrivances have been suggested for this purpose, and some valuable substances are thus procured. Coal-tar colours, mentioned at page 52, common tar, ammonia, used in smelling bottles and for many other purposes, with other substances too numerous to mention, are thus separated from coal gas in its impure state.

The gas thus purified then reaches the gas-holder, or gasometer, as it is more commonly called. This consists of an immense iron vessel, closed at all parts except the bottom, where it dips into another large iron vessel filled with water. The vessel that contains and stores the gas is so balanced as that it may rise when the gas passes into it. But sufficient of its weight is left unbalanced for the purpose of forcing out the gas through another pipe. By this the gas passes away into the "main," or large pipe, that conveys it into the streets. From pipes laid down before our houses the gas reaches us by means of smaller pipes, connected with the street mains; and thus we get, after many processes, the gas from coal to illuminate our houses.

There are numerous contrivances for measuring the gas, both as it leaves the gas-house and as it passes into the pipes in our houses. Their construction is too complicated to permit of explanation to our young readers. They are of two kinds—those measuring by the aid of water, and called "wet meters," and such as measure by a kind of elastic drum, called "dry meters," in which water is not used. The gas is sold at so much per 1,000 cubic feet—that is, one thousand parts, each measuring a foot high, deep, and wide. As the gas passes into either kind of meter it registers, by means of clock-work, the number of feet consumed, in tens, hundreds, and thousands of feet. The company employ men to go round to the consumers of gas so as to ascertain the amount used in each house; and they learn this by reading off the indications of the hands as shown on the face of the meter, much in the same way as we tell the time of day by looking at the hands of our clocks.

THE TALLOW AND WAX CHANDLER.

We have described the processes of making gas before speaking of candles or oil, because the subjects of gas and coal are naturally united. Indeed, at the present day, gas is rapidly taking the place of all other means of producing artificial light; for it is cleanly, readily obtained in all our towns, is cheap, and, with proper care, is safe for use in any place.

There are many kinds of candles, and it will be therefore best for us to describe how the commonest kinds are made in the first place, because all the improved articles have been derived from tallow, and their mode of manufacture is similar in many respects.

Tallow candles are made from the fat of animals, such as the ox, sheep, pig, &c., the two first affording the best kind. Large quantities of tallow are obtained from Russia and other countries, where the animal is frequently slaughtered and boiled down solely for its fat and skin. With us, the waste fat of the butcher, and the grease of our kitchens, driping, &c., go to afford tallow.

The first step in the manufacture of common candles is that of melting the fat, which is done in large iron pans, either heated by a fire placed underneath them, or by means of steam, which is far the better plan. As the fat melts, its impurities, as skin, dirt, &c., gradually settle down; and these, on being removed, are pressed into a cake, and form the "greaves" used as a food for dogs. The tallow is then removed into a clean pan, and, on being remelted, becomes fit for candlemaking.

The wick of a candle is made of coarse cotton yarn, and the number of the threads depends on the thickness of the candle. The larger the latter is, the more wick it requires to burn it. There are two kinds of tallow candles—viz., dips and moulds; and these are made in a very different manner: the "moulds" also require a better kind of tallow than the "dip" kind.

For making dips the candle-maker places on a long stick a number of wicks, each hanging downwards, at a distance of about two inches from each other. A number of these sticks are then hung in a frame, over a pan of melted tallow; and when the latter is just beginning to "set," or get solid, the wicks are lowered into it, allowed to remain a few seconds, and are then raised out of it. A portion of tallow thus adheres to each, and forms the first layer. When this is completely solid the wicks are again lowered into the melted tallow, removed, and cooled. By these dippings, coolings, &c., often repeated, the candles become sufficiently thick, and are then removed from the stick, sorted, and weighed, when they are ready for sale.

Mould candles are made by means of a tin mould, the inside of which is of exactly the shape of the candle. A number of these moulds are fitted into a frame, with the narrow end downwards. Through this end the wick is passed, and it is afterwards drawn up until it reaches the other or wide end of the mould, where it is fastened by means of a wire. The wick is thus kept quite straight, and in the centre of the candle when it is finished. Melted tallow is next poured into the moulds, and it runs down to the narrow or cone-like end, which it soon closes up. It is this end at which the candle is lighted. The moulds being quite filled are left to cool, and when quite cold the candles are removed. On being cut straight at the wide or bottom end, they are complete. We may here mention that "composite," "stearine," "sperm," and "paraffine" candles are all made in this way; but of these we must give a separate description.

Tallow candles have a great disadvantage, owing to their requiring snuffing; and to obviate this and other objections, many attempts were made to improve them. This led the way to the manufacture of candles we have just named.

Composite or stearine candles are made of the *solid* matter of fats; and we must here explain that common tallow contains several substances. Of these are its oily part, which gives tallow its softness; its solid part, called "stearine," together with "margarine," which has a beautiful pearly appearance, and "glycerine," so called from its sweet taste, and which is now so much used for anointing wounds, chapped skin, and in medicine.

The stearine is separated by converting the tallow into a soap, which is effected by heating it with water and lime. Sulphuric acid is then added, which separates the stearine and other substances. The stearine is then pressed with enormous force, to drive away all other substances, and after re-melting it becomes fit for making candles. There are many other methods of obtaining the stearine, as, for instance, by heating with sulphuric acid, distilling it, &c.; but our space forbids us describing them. Palm and cocoa, with other oils, are now employed in place of tallow; and it is from these materials, treated in the manner we have just described, that composite candles are produced.

Sperm candles are made from a solid substance found in the head of certain species of the whale, and called spermaceti. Margarine candles are obtained by using that substance obtained from tallow, as we have just explained; and all these are made in precisely the same way as the common mould. The wick, however, is very different, and the candles "snuff" themselves, for reasons which we must now detail.

Shortly after a common dip or mould candle is lighted, the wick begins to get long and black, and very soon the candle will require "snuffing." If, however, our young friends will try the experiment of bending a lighted candle in its stick, so that it may rest obliquely instead of upright, they will find that the *wick will gradually burn away*. In other words, the candle will snuff itself. This is owing to the air coming in contact with the red-hot wick, which it can never do so long as the wick is upright; and on this principle—by making the wick bend out into the air—composite and other such candles "snuff" their own wicks. We must add, however, that being made of more solid and better materials, the latter do not melt so quickly as tallow. For this reason the stearine, composite, and sperm candles form a little cup round the wick whilst burning, which tallow candles never do.

The wick of these self-snuffing candles is made *flat*, and is formed of about sixty or eighty threads of fine bleached cotton, plaited together in three strands by an ingenious machine, and in a manner similar to that adopted by ladies in plaiting their hair. Before being placed in the candle mould, they are dipped in a solution of borax or other salt, which, as it burns, forms a little bead that assists in bending the wick out of the flame. If our young readers notice the burning of a composite candle, they will see that the wick thus falls out of the flame, and they may also easily discover a little round bead at its end.

Wax candles and tapers are made in a very different manner. The wax is either obtained from the bee, and bleached by exposing it in thin sheets to the air, or the wax chandler uses wax obtained from plants; and of this kind much is sent to us from Japan and other countries. The wick is first covered with melted wax, and then rolled on a polished, warm metal plate; and by successive additions of wax, and rolling, the candle is completed. As wax melts only at a high temperature, a thin wick may be used, and this is generally of the same shape as that employed for mould tallow candles, but of much finer quality.

Paraffine candles are made of a substance obtained from a kind of coal, of which we shall have to speak under the next head. The mode of making them and their wick are the same as those employed for composite candles.

THE OIL MERCHANT.

LAMPS, OILS, PARAFFINE, ETC.

Although we have preferred to describe the manufacture of candles before speaking of lamps, we must remind our young readers that lamps, only, were in universal use in olden times. In most of our museums such lamps may be found. They are exactly of the shape of our tea-pots, and it was at the narrow-spout part at which the wick was burned, the body of the lamp containing the oil. In large rooms a number of these were hung from rods of brass, exactly resembling in form our modern gasaliers or chandeliers; and thus the rooms of the Romans, Greeks, and other nations were illuminated at night.

The sources of oil are very numerous, and in most cases the oil itself is obtained in the same way. Generally speaking, the seeds of the plants are used; and thus linseed, almonds, the seed of species of the cabbage tribe (producing colza, rape, and other oils), poppy, mustard, hemp, cotton, cocoa nut, sessamum, nuts of many kinds, with numerous others, afford us oil. The oils of the whale, called "sperm" and "train," according to its quality, the seal, walrus, cod, and other fish, are also largely used. The oil produced from vegetable seeds or nuts is obtained either by heat or pressure. Linseed, for example, is enclosed in coarse bags, and these are constantly beaten by heavy wooden hammers, until all the oil is pressed out. The refuse forms the oil-cake with which farmers feed cattle. Sometimes the seed is passed through heavy rollers, when the oil is forced out; and other kinds of nuts or seeds, after crushing, are heated in hot water, when the oil floats out, and is collected. In most cases the oil requires refining, which is done by heating it with water or acids.

Fish oils are obtained by heat from the fat, livers,

&c. The whale, for example, possesses an enormous quantity of a fatty substance called blubber, which completely encloses the body of the animal beneath its skin. The whale chiefly inhabits cold seas, and is killed by means of a harpoon driven with great force into its body. When quite dead it is hauled up to the side of the ship, and its blubber is cut out in large pieces and packed in casks, in which state it reaches this country, where it is refined by melting and other processes. By this or similar means most animal oils are prepared for use in lamps.

Paraffine oil, now so much used, is obtained by distilling a species of coal; and the chief source of this in our country is at Bathgate, near Edinburgh, where Mr. James Young, the patentee of the process now usually followed, has erected very large works. The coal is put into retorts, and heated to nearly a red heat, when it gives off a coarse kind of oil. This is refined by repeated distillation, until the spirit-part is completely removed; and it is owing to the careless preparation of other kinds of this oil that so many accidents have happened. Pure paraffine oil is not in the least dangerous.

A solid substance is also obtained towards the end of this process, which is the material of which paraffine candles are made. It has a beautiful and almost transparent appearance, contains no fat of any sort, but is simply a kind of condensed coal gas. In fact, a paraffine candle, when burning, is really a gas-house on a small scale.

Of late years immense quantities of oil have been obtained from rock, and it is called "petroleum," or "rock oil." It has different sources, being found with pitch at Trinidad, the Dead Sea, and many other places. Canada and some parts of the United States of America abound in wells, whence this oil flows like water. Indeed, so abundant and useful is this oil that a "farm" of it is more valuable than an ordinary "gold-field." It resembles paraffine oil, is similarly prepared, and has the same uses.

Such are the chief oils used for giving light. We must now say a word or two about different kinds of lamps and their wicks.

Lamps are of various shapes, but generally they are of two kinds only—namely, those with a solid, or such as have a hollow wick. The wick acts by drawing or "sucking up" the oil. This curious principle may be noticed by putting a piece of lump sugar into a dry plate. If a little water be then poured into the plate, it will be found that the liquid will rise far *above its level up the sugar,* and in like manner glass tubes, hairs, &c., will thus cause water or oil to rise. The little hairs or fibres of cotton wicks thus act, and so supply the flame with oil, and maintain combustion.

The old kinds of lamps have only solid wicks, like those of tallow candles; but the Argand, Moderator, and many other lamps, have hollow wicks, on both sides of which the air has access. The wick is stretched round a hollow cylinder, and overhead is a chimney made of glass, which, by creating an upward draught, draws up the flame, and acts in a precisely similar manner to the chimney of our fireplaces or furnaces. It increases the combustion, and therefore, at the same time, more light is afforded. In many lamps, as the paraffine, &c., a chimney is used together with a flat wick, and a similar result is produced. Oxydator lamps have the chimney contracted at a point a little above that at which the wick burns, and by thus increasing the upward draught of the air, also increase the amount of light given by the lamp.

We sometimes see in the streets a lamp which has no wick, such as is commonly employed by costermongers. In these lamps the coal-tar naphtha used is allowed to flow to the edge of small holes, and being then set fire to, heats the burner, which in its turn converts the spirit into vapour. This readily burns, and so a wick is unnecessary, a constant supply of the spirit being made to trickle down.

CHAPTER VII.

CHEMICAL MANUFACTURES.

Our young friends must not suppose that because we have headed this chapter "Chemical Manufactures," this alone contains an account of trades depending on the science of chemistry. On the contrary, there are few trades that we have mentioned which do not depend on that science, for we have seen that the dyer, bleacher, farmer, baker, the metal worker, and many others, must rely on chemistry for success in their operations. We have only used the title for this chapter because the trades we shall describe are almost exclusively "chemical" in their character, and depend less on other matters for their being carried on. We cannot give an account of all manufactures which might be included here, so we must make a selection of those that will be most instructive and interesting to our readers, and which have most to do with the concerns of our daily life. We shall commence with an account of how common salt is obtained, and then proceed to other matters of general interest.

SALT MINES AND SALT-MAKING.

Perhaps there are scarcely any substances afforded us by the mineral part of our globe which is more essential to our health than common salt. It abounds in our food, bodies, the water we drink, and in many other matters of our daily life. Cattle are extremely fond of it; and in many countries where the soil abounds with salt, they resort to such places, and seem to relish the water containing it.

Strange to say, common salt contains only a gas, chlorine—used, as we have seen, by bleachers, and mentioned when we spoke of that trade in the first chapter—united with sodium, a metal that takes fire on touching a piece of wet paper or warm water. So that when we partake of salt we swallow two substances, healthful when united, but dangerous poisons if taken separately. This is one of the many wonders that chemistry affords.

There are many sources of salt, amongst the first of which our young friends will doubtless think of sea-water, which contains a quantity of salt; but it is united with other substances which deteriorate its quality; and, again, so much water must be evaporated as makes the salt obtained expensive on account of the fuel required.

One chief source of salt are mines, of which we have large ones in Cheshire, at Northwich; and in Worcestershire, near Droitwich. In Poland, near Cracow, at the mines of Wielicza and Bochnia, there are immense salt mines; and from such sources our common salt for table use, and manufacturing purposes, as making soda and soap, is obtained.

The mines are well worthy of being visited; and when lit up, present a beautiful and dazzling appearance. The salt is found as a rock—hence called rock-salt—and dissolved in water, called brine-springs; and it is from the water of these that the salt is chiefly obtained.

The liquid is put into long, shallow pans, which are heated, and thus the water is driven off gradually. The brine-water is allowed constantly to run in, and at last, when sufficient salt is deposited by the driving off of the water, the pans are emptied. The salt thus obtained is again dissolved, and after being again heated, the liquid affords the salt in a tolerably pure state.

We have just hinted that salt is used for other than table purposes. The bleacher obtains his chlorine, or chloride of lime, from it and the soap-maker his soda. The process followed for this last purpose we shall describe after having explained how sulphuric acid, so largely used in our chemical manufactures, is produced.

THE SULPHURIC ACID MAKER.

We have often had occasion to mention sulphuric acid in describing various trades, but have kept our description of its manufacture for this part of our work, for it belongs essentially to it. The acid is a deadly poison, is very heavy, weighing nearly twice as much as its own bulk of water, and, from its oily appearance when shaken, is often called "oil of vitriol," so fanciful are names which are given to some things by workmen. We need scarcely tell our young readers that the acid does not contain a particle of oil; on the contrary, it destroys any, should they come in contact.

If we burn a sulphur match in the open air, an acid called the "sulphur*ous*" is produced. We have called attention to the bleaching powers of this acid already, when speaking of the trade of the bleacher. If sulphur, however, is burned in a vessel, and the fumes are allowed to mix with those of nitric acid obtained from nitre, with steam and air, in a close chamber, sulphur*ic* acid is obtained, and this is done as follows:—

Immense narrow rooms are built of sheet lead, about twenty feet high and one or two hundred feet long. Into these the fumes of sulphur heated in a pot; the vapour from nitre, produced by adding sulphuric acid to it, and so affording nitric acid or aqua fortis; with steam from a boiler—all these are sent into these leaden rooms together, and on the floor some cold water is placed. By a singular chemical change, which, if we were to describe it, our young readers could not understand, sulphuric acid is produced, and, trickling down the leaden walls, reaches the water.

After a time the water is drawn off from the bottom of the leaden rooms, and it contains, as we have already stated, sulphuric acid. This, however, is very weak, and only fit for the purpose of the bleacher. It is therefore concentrated, and this is done by boiling it in a platina still, this metal being used because every other would be dissolved by the acid. These stills are very expensive, costing about £3,000 each; and they are very heavy, as our readers may guess, when we state that, whilst lead weighs heavier than 11 times, platina is 21 times as heavy as its own bulk of water. Lead is used to form the chambers in which the acid is first formed, because it is scarcely acted on by the acid at the low temperature at which that is first produced.

Sulphuric acid has some very singular properties, which we may just name, to interest our young friends. If mixed suddenly with water, it produces so much heat as will set fire to a lucifer match and crack any glass vessel. It condenses water —that is, if equal parts of water and acid, say a pint of each, be mixed, the quantity will make far less than a quart. If dropped on any substance containing water and charcoal, it has so great an attraction for the former as to disengage the latter readily; and by such means the charcoal in sugar, bread, wood, and many other substances, may be readily produced. And lastly, if a shirt, handkerchief, piece of calico, or any other substance made of cotton, be boiled for a few hours with sulphuric acid and water, on some chalk being added to neutralize the excess of acid, as much sugar will be obtained in weight as the article first weighed! Our young readers will doubtless laugh at this, to them, new way of making sugar, but it *is a fact.* We shall next explain the manufacture of soda and soap, both of which depend, as we shall see, on those of salt and sulphuric acid.

THE SODA AND SOAP-MAKER.

An old saying has it that "Cleanliness is next to godliness;" and truly every good person must be a clean one. Few persons have an idea how necessary it is for health that the body and clothes should be kept perfectly clean. We have on our skin nearly seven millions of little holes or pores, through which our perspiration is constantly passing when we are in a state of health. If this perspiration be stopped, then we have "colds," fevers, and at last death. Hence it is of the utmost consequence that these pores be kept open. This is best done by an abundant use of water and soap, applied at least once a day over the *whole* of our bodies; for why should we only clean that portion seen by others, and leave the rest in a dirty state? But not only must the body be kept clean, but it is also equally essential that the clothes we wear should be clean also; for otherwise, having gathered the substances which have passed from us by perspiration, they will become exceedingly harmful to our health. These considerations make the soap and soda-maker's trade very important.

Soda used at one time to be obtained from sea-weed by burning it; but at the present day common salt is its chief source; and this is got from salt mines which are found in Cheshire and other countries. The salt is first treated with sulphuric acid, which drives off another acid; and here we may say that our common table salt consists only of a metal, which takes fire on being made to touch a piece of wet paper, together with the gas called chlorine (see page 244).

The substance or salt, called sulphate of soda, thus obtained by the action of sulphuric acid on salt is then dried, and mixed with small coal, after which it is placed in an oven and burned, or heated red-hot. By this means it is converted into a salt resembling washing soda in its properties, but to turn it into the latter article, it requires dissolving in water, and crystallizing, when it becomes the same soda used in our houses for washing purposes and cleaning generally.

The soap-maker employs this kind of soda for making hard soap—that is, such as we generally use for washing; but to make *soft soap*, he prefers to employ pearl-ash, a substance obtained by burning certain plants, and largely sent to this country from America. It is also called pot-ash, or pot-ashes, from the method of burning the plants in pots to obtain it.

The soap-maker uses these substances for the purpose of making oil and water unite together with them, soap consisting of these different materials; and the method of proceeding to make soap will be readily understood if our young friends try the following experiment:—Into a common phial put a tea-spoonful of olive or any oil, and some cold water, and shake them together. Of course, the two will not mix; but if an alkali, such as a little washing soda or pearl-ash, be added to them, and the bottle be then shaken up, the oil and water will unite, and afford a milky liquid, which in fact is *soap* dissolved in water.

This is the philosophy of soap-making. The maker uses tallow, resin, or various kinds of oils, and these he puts into a large iron pan with water. He then adds as much soda as is required, and boils the whole together for some hours, afterwards adding some common salt to separate the soap from the water. The soap at last forms, and rising to the surface, it is removed into square troughs. It is left there until it is quite cold and solid. The trough is so made that it can be taken to pieces, and when this is done the soap is cut by means of a wire into bars, piled away to dry, and becomes thus fit for use in our houses.

Yellow soap is thus made from tallow and rosin; "mottled soap" is produced by adding a solution of copperas (sulphate of iron), which thus produces the mottled appearance; curd soap is made almost entirely from tallow; and fancy soaps from various oils, with or without tallow, and scented with otto of rose, essence of bitter almonds, or other perfumes. Glycerine, a substance obtained from tallow, as explained at page 236, honey, and other materials, are often added, to soften the action of the soap on the skin; hence the name of the soaps so sold. And here we may mention that the cleaning power of soap depends on the alkali—soda or pearl-ash—that it contains. The oil is added to soften this action; whilst the water in it helps it to dissolve in that which is used with it for washing or cleansing purposes.

The use of soap has been long known, but various kinds of earths, as fuller's earth, clay, &c., have been used in place of it; and it is said that the earth from which meerschaum pipes are made is so employed in Turkey at the present day.

THE PERFUMER.

The perfumer's trade is amongst the oldest that we have described in this book; and our readers will not be surprised at this when they remember that at the present day we depend for the oils of which some of our best perfumes are made on flowers growing in the very countries in which man first lived, and where so many nations flourished and faded. In the Bible, and most old historical books, perfumes are spoken of as being constantly used, and their value, when scarce, often reached a fabulous amount. In the *Iliad*, *Odyssey*, and also in most books of the Latin writers, we find that after heroes had partaken of the bath, they employed perfumes; and in our day, although we do not carry extravagance to such a length, still perfumery is a trade which nearly every civilized person has more or less to do with.

The perfumer occasionally prepares or obtains the oils he uses; but large quantities are produced in the countries where the flowers grow, and are sent here ready for his use. But we must remark that it is not flowers alone that afford us perfumes. They are also obtained from the wood, as in cedar and sandal-wood; from the leaves, as lemon-grass, rosemary, lavender, &c.; from the fruit, as the lemon, bergamot, clove, nutmeg, &c; the barks of some plants afford them; and in rarer cases the roots of plants are had recourse to.

There are various ways of obtaining the perfume-oils from plants; and here we must remark that these oils differ from those we have spoken of as used in lamps. All oils are divided into *fixed*, as the olive, almond, &c., which will not evaporate at a low heat; and into *essential* or *vegetable*, which will evaporate. Thus, if a drop of olive oil and one of otto of roses be put on a piece of paper, and held over a candle, the olive oil will not evaporate, but will remain on and stain the paper. On the other hand, the otto of roses, *if pure*, will entirely evaporate; and this, indeed, is the general method of testing its purity. Hence it is the *essential oils* alone that are used by the perfumer, for he depends entirely on this property of the evaporation at common temperatures for his success in making "scents."

We must next explain how the essential oils are obtained from the flowers, fruit, &c., and the mode adopted depends on the article used for the purpose. When flowers are employed, the most usual plan is to soak the petals or leaves in brine, made by dissolving salt in cold water. This method not only extracts most of the oil, but it has the advantage of not injuring the leaves, and prevents them becoming putrid. Hence leaves so steeped may be sent all the way from India, and the oil can then be separated by means we shall shortly describe.

Another method is that of soaking some threads of cotton yarn, such as is used for lamp-wick, in oil of ben, or the best olive oil, and placing the leaves of flowers on them. After a time the essential oil will leave the flowers and attach itself to the fixed oil. Sometimes simply steeping the leaves, &c., in hot or cold water will do; and what is still better, soaking them in good spirits of wine, which, generally speaking, unites with and dissolves the oil. If lemon or orange peel be rubbed on a piece of loaf sugar, the oil is easily obtained; or if leaves, flowers,

&c., are pounded in a mortar with fine chalk, the oil may frequently be separated with ease.

By each and all the methods we have described the oil has been removed from the flower, but only to unite with another substance; and it still remains to separate it so that we may possess it in an unmixed state. For this purpose the brine, oil, &c., must be distilled; and this is done by using a still similar to, but smaller than that we spoke of as generally used by the distiller. The liquor is put into the body of the still and heated; after a short time the essential oil passes over into a little water kept in a vessel at the mouth of the worm; and it may be easily detected floating on the surface in little drops, for essential, like the fixed oils, are insoluble in water, or, if soluble, are so to a very slight extent.

The business of the perfumer consists of dissolving the oils in spirits of wine in such quantities as may suit his fancy and that of his customers; and also of selecting such as, when united together, will afford a pleasing perfume. Of course, this not only requires great judgment, but a refined taste; and as our French neighbours excel in the latter respect, we need not feel surprised at the success their perfumers can boast of.

Eau de Cologne, with which all our young readers are acquainted, is combined of several oils dissolved in spirits of wine. The object of the solution in that liquid being to dilute or lessen the smell of the oil, and to afford a medium of mixing several together. Some perfumes which, when so dissolved, afford a delicious smell, are almost offensive when applied to the nose in an undiluted state; and others are so strong as to be injurious if smelt alone.

We may now mention some of the leading oils used by the perfumer, and must begin with otto of rose as the most costly and delicious. It is obtained in various parts of Asia Minor and Syria from a kind of rose grown expressly to produce it; and an immense quantity of leaves is required to produce even a small quantity of the attar or otto. Our own roses contain it, but in quantities too small to make it worth while to extract it. Neroli, another favourite and very expensive perfume, is obtained from the flowers of the orange tree: it is reckoned next in value to the otto of roses. Lemon oil, or lemon-grass oil, is obtained from a species of grass native in India. It is much used in making the scent called verbena. Lavender, also, is a favourite oil, and that produced from English flowers is preferred—a rare exception in oils used by the perfumer, they being usually best produced in hot climates. Bergamot is obtained from the rind of a species of orange; cedar-wood and sandal-wood afford oils used by the perfumer; and amongst others we have not named, those called citronelle, clove, jasmine, patchouli, sweet-flag, winter-green, &c., form a portion of his resources.

But the last and most curious sources we have yet to refer to. Chemistry, as we have often stated, produces astonishing results; and perhaps nothing will more surprise our young readers than the fact that most of the oil of bitter almonds now used is got from *coal-tar*, that stinking refuse of our gas-houses used to cover palings, &c. But further, pine-apple, apple, pear, jargonelle-pear, strawberry, and other flowers and perfumes, are not now got from the fruits that bear their names, but from *rancid butter and cheese.* The methods used are too difficult to be understood by our young readers, and we only name the fact as one of the most interesting discoveries made for a long time past. Most of the ices, acid-drops, &c., sold at the shops are flavoured with the liquids thus obtained.

Fancy soaps are perfumed by using the oils we have described: but these we have mentioned under the head of the "Soap-maker."

THE WHITE LEAD MAKER.

When we tell our young friends that nearly all the white paint which is used in our houses and other buildings is made from white lead, they will see that the trade or manufacture of it is of no small importance; and as it is an entirely chemical process, we shall devote a little space in describing how it is manufactured.

Common lead is, as we all know, a heavy metal, having a bluish-white colour. If a clean and polished piece be exposed to moist air for a few days it will be covered with a thin white crust, which arises from the action of two gases in the air—namely, the oxygen, or vital portion, and the carbonic acid gas, which we spoke of when describing the trades of the "Brewer," "Distiller," and "Baker." Now, this white crust is an impure kind of white lead; but the result sufficiently explains the principle on which the manufacturer proceeds.

The lead is rolled into thin plates, and arranged on racks or pots, beneath which spent tan, the refuse of the tanneries, is placed. The pots contain a coarse kind of vinegar, and as the tan gets hot, which it will do when heaped together, the vinegar is caused to evaporate. On the acid it contains coming in contact with the plate of lead, it acts on the surface of the metal, producing what chemists call the acetate, but which is sold in the shops as "sugar of lead." This substance, however, is acted on by the carbonic acid gas that rises from the spent tan; and the gas thus converts the lead-salt into what chemists call the carbonate of lead, but what in trade is sold as white lead.

When the outsides of the metal are thus turned into white lead, the plates are taken away, and all the white powder is removed; the plates, however, are returned to the pots, so that they may be gradually "eaten away," or turned entirely into white lead.

The white powder is at last ground up in a mill, with oil or water, according to the purpose for which it is required, and in either case is ready for the painter, whose trade we shall have afterwards to describe.

We may add that making white lead is a most poisonous trade, and gradually but surely ruins the health of all who are engaged in the practical part. For some unknown reason, women are less injured than men, and hence they are mostly employed in the works. Of late years preparations of zinc, called white zinc, baryta, and other substances, have been used, but the painters do not like them, because they do not afford what is called "body" to the paint made from them. The object for using them was to save the health of both the white lead maker and the painter; but it has not succeeded, so far as we know, for the reasons just named.

MISCELLANEOUS CHEMICAL MANUFACTURES.

The articles we have already described as resulting from chemical manufactures are of great importance in our daily life; those that we have yet to mention are also valuable, but chiefly so for special purposes. We shall therefore embrace them under the head of "Miscellaneous," and commence with

Alum.—This substance is much used in dyeing, tanning, medicine, and for other purposes. It is produced from a kind of clay or shale, which is obtained from mines. Those which we have seen at

Hurlet and Campsie, near Glasgow, are the most valued, and their description will therefore best suit our purpose.

The shale is contained in thin beds beneath the surface of the ground, and is of two sorts—the powder-like and stony kind—which have to be treated in a somewhat different manner.

The powdery kind, after being brought up to the surface, is put into large vats called "steeps," in which water dissolves away all that is soluble. The liquid so obtained is then transferred to boilers, in which hot air is conveyed over the top of the liquid, instead of heating it underneath. It is then removed to coolers, and here, owing to the "copperas" or sulphate of iron being easily crystallized, is thus separated from the alum solution. But this will not crystallize until potass be added to it; for alum consists of sulphuric acid (see page 245), alumina, or the earth of common and potter's clay, united with potass. So the alum liquor has that addition made to it, and on being evaporated affords crystals of alum, which all of our young readers will know something of.

When the hard or stony ore is used, it has to be roasted, by burning it in heaps with small coal, after which, by the action of air and moisture, together with the processes already described, it will afford the same kind of alum. The only difference between the ores is that the soft has been already prepared by the action of moisture and the air, whilst the hard kind has not. Hence the additional process of roasting in regard to the latter.

There are other methods of making alum, but the one we have described is that most usually followed.

Glue.—This substance is largely used in a variety of ways; but to the carpenter and cabinetmaker it is absolutely essential. It is produced by boiling waste skins, and other matters which abound with gelatine—in fact, size. The gelatine sold in our shops as lozenges, &c., and isinglass, with even "calf's foot jelly," are all the same thing, only obtained from different sources. The commoner article of glue, however, is got from the coarsest materials. When extracted, it is a thick liquid, and on being poured out on to metal trays it gradually becomes solid. It is then removed and hung on netting in a warm dry room, by which it is made hard and brittle. The cross lines seen on pieces of glue are caused by marks made on it by the netting whilst the glue is in a soft state.

The name glue is also applied to other substances mixed with glue, as gutta percha, &c. Hence "marine glue," which will stand the action of water, which common glue will not. Glue mixed with treacle forms the material of which the inking rollers used by printers is made. It has the advantage of readily taking up and spreading the ink, whilst at the same time it is so elastic as to be uninjured by the type metal which rubs against it.

Size, used for whitewashing and many other purposes, is only a weak kind of glue; but it is chiefly prepared from the skins of animals. Its froth is used to give the glazed coating to waddings, as mentioned at page 15.

Starch.—This useful domestic article is produced by every plant. Indeed, as we have stated, when speaking of wheat, at page 95, it is essential to the sustenance of our bodies, affording, as it does, a large amount of heat during its combustion when changed into blood.

We pointed out at the page just referred to how starch may be obtained from vegetable matters, and precisely similar plans are adopted by starch makers. The material—say wheat, potatoes, &c.—is beaten up in water until the starch, which is *insoluble in cold water*, is quite separated. After allowing it to settle, it is frequently washed, and at last, after being coloured with a little indigo, if required for laundry purposes, it is dried, weighed up, and packed in bags, &c. If packed wet, it cracks up, as it dries in the bag, into the singular forms which our young friends must often have noticed in opening a packet of starch.

Potatoes which have been rotted, or have turned bad, are much used for making starch for calico dressing (see page 42); and the starch, if heated highly, becomes converted into "British gum," which is so largely used to make the back of postage stamps adhesive.

One word to our young—but especially lady—

friends on the philosophy of making starch. We have said that starch is insoluble in cold water. If, however, it be mixed with *boiling water*, a singular result takes place. The starch is really enclosed in little bags called "cells," and these, when they come in contact with hot water, burst. The starch then gets free, and produces that jelly-like substance called "starch" by laundry-women.

Such are a few of the trades which are chiefly carried on as chemical manufactures for our domestic use. We shall conclude the chapter by giving an account of the manufacture of lucifer matches.

THE "LUCIFER" MAKER.

In our younger days—say about thirty years ago—we remember that the only means of getting a "light" in our houses was the old-fashioned "tinder-box," with the flint and steel. A piece of thin steel, of something of the shape of a hooked door-handle, was held in the left hand over the fingers, and the steel was struck forcibly with a sharpened flint. The sparks then produced were received on a piece of calico which had been burned black, and placed in a box; hence the name "tinder-box." As soon as the tinder caught fire, a match made of a thin slip of wood, pointed at both ends and tipped with brimstone, was put on the burning cloth, and thus the match was set fire to.

Our young readers will think that this was a most clumsy arrangement; and it was not only that, but also exceedingly painful at times, for frequently the flint slipped off the steel and struck the fingers, of course producing a wound.

The first substitute which we remember for the tinder-box was matches coated with a mixture of chlorate of potass and sulphur. On the coated end being dipped into a little sulphuric acid, it caught fire, and so a light was obtained; but the plan was a bad one, for if the acid dropped on the hands or clothes it burned them seriously.

Our next remembrance brings us to the lucifer match-box, which consisted of a chip-box, holding about fifty matches, the ends of which were set fire to by rubbing them between two pieces of sand-paper, or rather one piece bent double. This was a great improvement, but very often the matches did not act. Besides this, they were very expensive, for we have not forgotten that on one occasion, being anxious to possess a box, we had to pay no less than *sixpence* of our pocket-money in purchasing a small one.

The greatest of all improvements was that of using phosphorus in making matches; for that substance ignites readily on being rubbed against any rough hard substance, and therefore is just the article required in making an easily lighted match. If we are right, these matches were first called "Congreves," on account of their having been invented by a person of that name; and we must now describe how those in general use are manufactured.

But first as to the materials. Sulphur is obtained from various parts of Sicily, a neighbourhood abounding with extinct and ever-active volcanoes, as, for instance, Etna. The Lipari islands, near Sicily, also supply a large quantity. The reason sulphur is used depends on the fact that it catches fire at a low temperature, and so tipping the matches conveys the heat from the phosphorus to the wood, which it thus sets on fire.

Phosphorus is obtained from bones; for, strange to say, our bones and those of other animals contain a large quantity of that substance. The bones, after being dried, pounded, &c., are mixed with sulphuric acid (see page 245), by which they are decomposed, and their lime is taken from them. Phosphoric, or the acid of phosphorus, is thus set free; and this being distilled with charcoal, affords phosphorus, which, when thus obtained, has an appearance resembling something between cheese and yellow wax in colour and consistency.

Vermillion, chlorate of potash, a substance resembling nitre in most of its properties, and other materials, are also used; and these, with the phosphorus and some sulphur, are made into a kind of paste. Into this paste the matches, already tipped with sulphur by having been dipped in that substance when melted, are introduced, and thus the end becomes coated with that red or other coloured matter which we notice as one part of the common "congreve."

"Silent" and noisy matches depend on the quantity of phosphorus these contain. But we may here remark that the silent ones are generally dangerous—that is, they are far too readily set fire to. Hence, as a rule, they should not be used in houses. Lately, a very ingenious and safe match has been invented, which cannot be ignited except it is rubbed against the box with which the match is sold. On the back of this, in place of the common piece of sandpaper, is a substance containing what is termed amorphous phosphorus. This will not catch fire unless rubbed by certain chemicals that are found at the end of the matches. So, as the matches and box cannot be made to "give a light" unless used together, no danger can ensue.

The splitting or making of the match itself is done by a very ingenious machine, by which thousands can be made in a few minutes. The rest of the work of making matches is done by young women and children; hence the reason why "lucifers" are sold cheaply. The trade, however, is a very unhealthy one, as carried on in this country, for the phosphorus so acts on the workmen as to speedily cause a disease for which there is no remedy yet found.

How trifling an affair is a lucifer match! We scarcely think it of the least value, and yet it involves in its make and use some of the highest laws of science. In a business point of view, however, it is no "trifle," for it employs many thousand persons, both here and abroad; whilst there is perhaps no part of the world where civilized man has been where we could not find some traces of a "lucifer match."

CHAPTER VIII.

TRADES CONNECTED WITH BUILDING, ETC.

We must now turn to a series of trades in which every one of our readers has an interest. We refer to such as relate to the building and furnishing of our houses. Many trades we have already described are concerned in different matters of which we shall have to speak: it will be unnecessary, however, that we should again describe them, for we shall mention where such are to be found in this book. In future we shall confine ourselves only to those trades that particularly relate to the subject we have now in hand.

But before describing these, let us have a glance at the different kinds of houses which have been, and even are now, used by various nations; for such will instruct us much as to the improvements which art and science have afforded us; and not only so, but we think that many of our young readers will be much amused at the singular contrivances which in some countries are dignified with the name of "houses."

In Greenland, and many parts of North America, "snow houses" are the rule; and they are not, as might be supposed, *cold* houses. On the contrary, they are exceedingly warm. They are built in the shape of a dome—just like half an india rubber ball in shape—out of "bricks" cut from the snow, piled one on the other. A long tunnel of snow is made, by which the inhabitants enter and leave the house, and the door is formed of a lump of snow. In the middle a lamp is hung, which not only lights the house, but also warms it, and affords heat for cooking. From the smoke of this lamp the soot rises so rapidly as soon to cover the inside with a kind of black paint; and this assists in two ways to keep the "house" warm; for, not conducting heat readily, it prevents its escape, and also stops the melting of the snow walls.

Snow houses are warm because that material is a bad conductor of heat (see page 2), and hence it is the best that can be used for building purposes in very cold climates. By the wisdom of the Creator, the plants in our climate are protected from destruction by frost whenever a fall of snow takes place, for it prevents the escape of the natural heat of the plant covered by it.

We will next visit some of the "houses" of the lowest kind that may be seen in our own land, and for that purpose shall visit the north of Scotland. A few years ago, whilst in the North Highlands, we first visited one of these. We have seen many since, and shall select one for the amusement of our young readers.

On approaching this, we found its walls made of a mixture of mud, straw, and stones; the roof was of thatched straw. For some time we looked for an entrance, and at last found a low opening under which we had to bend much before we got in. The "building" was about eight feet square and six feet high; there was neither fire-place nor chimney; a stone on the earth floor served for the former, and a hole in the roof for the chimney. The "furniture" consisted of a three-legged stool, a tub, and the stump of a good sized tree. The "bed" was nothing but a layer of straw on the floor. In this hut lived an old man and woman, with a lad, their grandson. These folks seemed quite contented, and, we are happy to add, pious; for when we entered, we found all engaged devoutly at evening prayers. We thought, indeed, of the old saying, "Godliness with contentment is great gain."

In Ireland far worse habitations are to be found. There we have entered mud-huts, and eaten in company with men, women, children, cocks and hens, ducks, pigs, and a pony—all in one place! The birds and four-footed animals walked in and out as they liked during the day, but at night all these beings were huddled up in this place. It is painful to think that in our own country such wretchedness and misery should exist. But perhaps we are wrong, for the human beings we have thus seen are generally gay, light-hearted, and thoughtless.

The poor in many European countries are frequently housed in a similar manner. Those who emigrate to foreign lands are often obliged to build temporary houses of logs of wood, &c.—hence called log-houses. These are common in the wilds and forests of Canada. In Indian and many savage countries, skins, leaves of trees, wicker-work, and such other contrivances are resorted to.

The better class of houses in all countries are generally built of a material, and in a manner, which most conduce to the comfort of the inhabitants. Pompeii, which was suddenly destroyed by an eruption some two thousand years ago, gives us an excellent idea of the houses which the Romans used; and a model of this, and of many ancient and modern foreign houses, may be seen at the Crystal Palace, at Sydenham, which we must leave to our young friends to visit, as we cannot spare space here to describe them.

In this chapter we shall describe the materials now used to build houses, in the first place, in connection with the trades that produce them; secondly, we shall mention such trades as are engaged in constructing, painting, and otherwise finishing our houses; and lastly, the furnishing of them, and the trades engaged therein, will be dealt with.

THE STONE QUARRY AND MASON.

Stone for building purposes is obtained from many parts of our kingdom, Bath and Portland being the chief sources of what is often called "freestone," so named because when fresh obtained it is readily cut by a saw, although it speedily hardens on being exposed to the air. But most of our counties afford stone fit for building, some stones being much harder and more durable than others. In Scotland, as at Glasgow, the stone is obtained close to the city, and hence nearly all the houses are built of that material. The city of Aberdeen, which is near granite quarries, is built chiefly of granite; whilst in London, which abounds with clay, bricks are chiefly used, and stone houses are expensive, because no building-stone is obtained near that great city.

The place whence stone is obtained is called a "quarry," and the material is met with in immense masses at various depths below the surface of the ground. When the soil, &c., covering it has been cleared away, the next step is to cut or separate pieces from the mass, and this is done in a variety of ways. One method is that of driving in chisels at a foot distance from each other, and thus, by hitting them with heavy hammers, blocks of moderate size are gradually broken off. If the stone be very hard, holes are driven in by means of crowbars, such holes being three or four feet deep and two or three inches across. These are then filled with gunpowder, and a fuse is attached, which burns a certain length of time, so as to allow the workmen to get to a safe distance before the gunpowder catches fire. By this means lumps of irregular shape are broken off in all sizes, which require to be trimmed into shape before they can be used. Another method is to drive in *dry* wooden wedges, and these on being wetted swell so much as to readily break off larger blocks. In a similar manner, during winter, granite is removed by means of water. A kind of deep ledge is cut by means of a chisel, and filled with water, which, as soon as it freezes, increases so much in size as to break the rock. It is for the very same reason that lead pipes in our houses burst from the increased bulk of water which occurs when that liquid freezes. This singular exception to the rule, "that all bodies expand on being heated, and contract on cooling," is of great importance in nature, for if water got smaller in bulk as it froze, ice would sink, and so our seas would soon become a solid mass of ice, which could never be melted. It is for this reason also that icebergs swim on the surface rather than sink in the ocean.

The business of the stonemason consists in cutting or shaping the stone thus got, and he does this by means of a saw if the stone be soft. The saw is fitted to a large frame hung from a beam over head, and by his hands the mason shifts it to and fro, and thus causes the teeth to penetrate the stone. Water and sand are allowed to drip together on the edge of the saw, and they much assist its action. Sometimes the steam engine is employed to cut stone after this fashion.

If the stone be very hard, it cannot be worked in this manner, and in place of the saw a hammer having a sharp end made of steel is used. This gradually chips away small pieces either with or without the help of a chisel. At Aberdeen large works are carried on in which granite is cut and polished in sizes from the largest column or gravestone down to that of studs for the shirt. The latter look very pretty when polished and complete.

Marble is chiefly obtained from Italy, at Carrara, where there are many quarries; but Ireland and some parts of England afford a somewhat similar material. There are many other substances employed in place of marble, as, for example, serpentine, porphyry, &c., but only to a small extent.

The ornamental pieces of stone used for the fronts of public buildings, columns, &c., are cut out with the hammer and chisel, the design being first drawn out on paper. But now-a-days such work is generally done in cement, because that can be readily moulded into any form, and is very durable. The outsides of brick houses are thus apparently "turned into stone," and when painted regularly, last as well as stone itself. The material is termed "stucco."

It is of great importance in building with stone that a durable sort should be used, for if care be not taken in this respect, the surface is soon acted upon by air and moisture, and rapidly wears away. This has occurred at the Houses of Parliament, in building which "dolomite," a kind of limestone containing magnesia, was used. The ancients were very careful in this respect, and hence their buildings have lasted many centuries. But they had also the advantage of drier air than ours, and no smoke from coals, which does much in injuring the outside of stone buildings.

THE BRICKMAKER.

Brickmaking is a very ancient occupation. It is spoken of as the task imposed on the children of Israel when prisoners in the land of Egypt; and the remains of edifices three or four thousand years old testify that the use of bricks has been known long before the time when accurate history takes its date.

But ancient bricks were not prepared in the same way as those we use. They were made of various materials; and it is most likely that when clay was used in their manufacture, the bricks were not baked as they now are, but were hardened by simply exposing them to the rays of the sun. In the climate of Syria, Egypt, &c., the sun-heat is sufficiently powerful to dry and harden bricks used in those countries, for the climate there is not so injurious to stone and brick as is our own.

Brickmaking in our day is really the turning of soft clay into a kind of hard stone, by heat and the use of proper materials; and although a brickfield seems at first sight a place which of all others we should least expect to involve science, still a good deal of science is required in choosing the materials, uniting them in proper proportions, and lastly of baking them to the right degree of hardness.

Clay, chalk, and waste cinders, called "breeze," are the materials which the brickmaker employs. The clay forms the staple of the bricks, the chalk forms the cementing material after being burned, and the breeze or cinders enable the brick to burn in the kiln.

In making bricks the clay, &c., is prepared in the autumn of the previous year. This is done by throwing it into a pit a few feet deep, and casting on it, in layers, chalk which has been ground up with water, and breeze on the two other materials; and thus, in the order of clay, chalk, and breeze, the pit is gradually filled up. In the next spring, as soon as the brickmaking season commences, the men turn over this mixture with a spade, and so mix its contents still more completely. It is also well wetted with water. The clay is then thrown into a pug or horse mill, which consists of a tub in which iron rods or coarse knives are made to rotate, and moved by a horse. Most of our young readers must have seen one of these simple machines at work.

As soon as the materials are completely mixed and softened, the clay is removed in barrows, and put between a small wooden mould, the latter being dusted over to prevent the clay adhering to its surface. The bricks are thus formed, and are then wheeled away and piled up in long rows, so that they may dry in the open air. They are lightly covered with heaps of straw, which prevents the rain wetting, or the frost from freezing them.

The next business is that of baking. The bricks, when dry, are piled up in a large square, so that they do not touch each other at the side, openings being thus left to act as chimneys between the bricks. A fire is lighted at one end, and this, seizing hold of the "breeze" in each brick, gradually spreads throughout the kiln, until every brick except those outside, which are generally old ones, has been made red-hot. Care is required lest too great a heat be caused, for then the bricks would melt and unite together—a circumstance which often occurs, and causes loss to the maker, owing to the salts which the clay contains, and which thus accidentally acts as "glaze" does to pottery.

When the kiln is quite cool, the bricks are taken from the kiln and sorted. They are sold by the thousand, according to their quality.

Of late years brickmaking machines have been much used. These are "fed" with clay at one end, and by a very ingenious arrangement they convert it into complete bricks, which are delivered at the other end ready for drying and baking. These machines are, however, not suitable for every kind of clay, hence brickmaking by hand is by far the most common in many places.

The brickmaker is a hard worker, for he and his family sometimes begin so early as three o'clock in the morning, and work till six or eight at night.

They are obliged "to make" bricks "whilst the sun shines," for that is impossible in winter, owing to the frost and wet weather, which would destroy his labour.

THE LIME BURNER.

Stone and bricks, however suitable for our purpose in building, would be of little use if they were not cemented or fastened together by mortar; and this substance, in turn, could not be made without lime, for reasons we shall presently explain. In old times, however, and in some places at the present day, a kind of pitch is used, that is obtained from wells and lakes, as the Dead Sea, Trinidad, and other places; and this is most likely the same substance as that called "slime" in our Bible.

Lime is obtained from various sources, and is contained in chalk, which the rocks in Kent, at Margate, Ramsgate, Dover, and other places in our kingdom, are composed of. Mountain limestone is also much used, and this affords "hard," whilst the chalk gives "soft" lime, when burned. Some is much used also as a manure; and hence, wherever farms are situated on chalk or limestone, our young friends may find a lime-kiln.

This is a very simple affair. Sometimes it is built of bricks, in a kind of dome-like shape, but more generally it is dug out of the rock from which the chalk or limestone is obtained, and faced only in front with bricks. Into this kiln the chalk or limestone is thrown with coals, and on the latter being lighted they gradually make the stone red-hot. By doing this, the carbonic acid, which, united with lime, forms chalk, &c., is driven off, and lime itself is set free.

The pure, caustic, or burnt lime, has a yellow appearance, and when thrown into water, hisses, owing to the great heat which it produces when in contact with that liquid. Indeed, this curious property gives rise to serious accidents. We have seen places that have been set fire to solely by water, as rain falling on new-made lime. Sometimes the bricklayers, whilst building a house, take advantage of this to boil their breakfasts. They put the tin can containing their coffee or tea into a lump of new lime, and wet the latter with water. So much heat is produced that the coffee soon boils, and in this way our young readers may easily *boil water with cold lime and cold water!* The steam which rises when mortar is made is produced for the reason we have just explained.

Mortar is made by mixing new lime and sand together, and making them into a kind of stiff paste. Cow, or short horse-hair, is added in small quantities, to hold the pieces together after they dry. Now, the reason mortar is so effective in holding stone and brick together is this. As it is exposed to the air, the lime it contains gradually absorbs carbonic acid gas, which the atmosphere always contains, and so the lime is thus converted again into chalk. Our young friends may study this by shaking up a piece of *new* lime in a bottle of water for some time. They must then cork it, and allow the liquid to settle. When quite clear, the transparent water is to be poured into a saucer or plate, and exposed to the air. A thin skin will soon form over the surface, and this skin is *chalk*. If it be broken, another will form, and so this continues until all the lime is converted into chalk. It is precisely this action which constitutes the valuable quality of common mortar.

Cements are merely earths containing a portion of clay, lime, and sand, and which are heated so as to make the lime caustic. When these are mixed with water, they soon harden, and are used to make the stucco parts of houses, so that such may resemble stone. Of this kind are Roman, Portland, and other cements.

Plaster of Paris is a salt of lime—that is, it is lime united with sulphuric acid, and called sulphate of lime by the chemist. On being heated, it attains the property of hardening quickly when mixed with water. It is called plaster of Paris because the neighbourhood of that city affords the material for making it. Ceiling ornaments, plaster casts, &c., are made of it, and it is much used both by the plasterer and whitewasher.

Whiting is merely chalk ground up and made into cakes. It is also much used in the trades just named, and which we shall shortly describe.

THE TIMBER MERCHANT.

Besides stone, brick, and mortar, which are the "raw materials" for house-building, wood is required for forming the floorings, staircases, roof, &c., and we shall therefore describe the different kinds used at the present time.

In this country pine is largely consumed. It is obtained from various species of fir, and the tree, when sawn into rough boards or planks, affords a kind of the well-known "deal." It is soft, easily worked, and therefore is very suitable for the purpose of house-building. It is obtained from Norway, Canada, &c., and is also largely grown in this kingdom, but more for ornamental than useful purposes, as our land can be more profitably employed. In Norway and Canada there are immense forests, which afford an abundant supply of the wood. The flooring, partitions, doors, and wooden frames of the roofs of our houses, are made of deal.

But there are other woods which, although of more limited use, are employed in building, cabinet-making, &c.; and it will be proper that we should give a short description of these, as it will save repetition when we come to speak of various trades in which they are used. We shall take them in alphabetical order, as forming the general stock of the timber merchant.

Beech and birch are much used for making chairs, tables, and legs of bedsteads. They are natives of our own and similar climates. Cedar is made up into various kinds of cabinet work, but it is too soft for articles much in daily use. Elm, which grows abundantly in England, is employed for making objects much exposed to wear, or which must be durable; hence it is very suitable for stairs, out-door work, and is the wood employed mostly for coffins. Fir we have already named as affording deals. Mahogany, as all our young friends know, is a wood used in making furniture, railings for staircases, &c. It is grown in hot climates, such as Cuba, Honduras, and adjacent countries. Being a hard wood, and having a beautiful grain, it takes a good polish. Maple, which grows largely in Canada, is another wood used for ornamental purposes. It has a pretty appearance when polished, and is much employed in making door and other panels, pianofortes, cabinet work, &c. Bird's-eye maple, so called because the spots resemble the eye of a bird in shape, is mostly prized for such purposes. Oak is a most valuable kind of wood, and that grown in England is most highly valued. It is very hard, takes an excellent polish, and is very durable. Its uses are very numerous in the house; for palings in our gardens; and ship-builders require much of it, as it forms, with few exceptions, the best material they can use. In Hampshire, especially the New Forest, the oak is largely grown; but foreign oak is also used: and teak, which seems to be a good substitute both for mahogany and oak, is accordingly often employed for similar purposes to those woods. It is obtained, however, from an entirely different kind of tree. Norway spruce affords white deals used in building, &c. Rosewood is obtained from the Brazils, and is largely used in making ornamental furniture, on account of its colour and the fine polish which it takes. Satin, silver, and tulip wood are similarly employed, but chiefly for small articles. The walnut also affords a beautifully marked wood, used for making tables, chair frames, pianofortes, &c.

We have named but few of the numerous woods employed, for others are rarely used. Since the Exhibitions of 1851 and 1862, great numbers of foreign woods have been introduced into this country from China, Japan, Australia, and other places. The wood from the Australian gum-tree is very valuable, and in many respects resembles mahogany.

If our young friends can visit the Museum of Economic Botany at Kew, in the centre of those beautiful gardens, they will see specimens of hundreds of useful and ornamental woods obtained from various parts of the world; and the visit will not only be very interesting, but highly instructive.

We must now speak of the preparation of wood for use in building, furniture, &c.; and in every case the first step is to "season" it. The tree is generally cut down by aid of a long saw and hatchets, applied at a little above the surface of the ground on the trunk or body of the tree. When it is "felled"—that is, cut down—the branches are lopped off, leaving the solid stem or "trunk" in the shape of the tree, which is converted into a "log" by removing the bark and straightening the sides with an adze.

In this condition "logs" of mahogany, fir, spruce, &c., are imported into this country, and with the exception of the first named, they are kept in ponds of water called "timber-ponds," by which the sap of the tree is gradually removed. This is very essential, for otherwise the wood would soon rot and be useless. There have been many processes invented for the purpose of preserving wood, and this is most effectually done by forcing into it creosote, a substance obtained from pitch and tar, salts of metals, &c. The object is to destroy the sap by chemical means, and to prevent rot. The logs are put into large vessels, like the boilers used for steam engines, and every part is made quite air-tight. The air in the vessel is then pumped out, and the preserving liquid, on being admitted, rushes into the pores of the timber. This is aided by forcing it in with great pressure; and at last all the sap is not only removed, but entirely replaced by the preserving solution. Sleepers for railways are always thus protected against the action of air and moisture, which would otherwise soon destroy them.

We have only gone so far as to describe the con version of timber into logs: we must now deal with another business, by which the wood is sawn into planks, &c., and so prepared for the carpenter, joiner, and other such trades.

THE SAWYER.

It is the business of the sawyer to cut up the logs spoken of under the previous heading into planks, boards, &c.; and two methods are adopted for this purpose—viz., that by hand, and the other by machinery.

When the sawyer receives a log, it is placed on an upright frame, underneath and on which is a man. A long saw, furnished with two handles, is used, and this being introduced into the timber, it is worked by the men from one end to the other, and thus planks of any thickness may be cut. This, however, is a slow process, and therefore machinery is largely employed in place of human labour, in most of our large towns, for sawing purposes. Two or more saws are fixed together in an upright frame, and at such distances as the thickness of each plank or board requires. The saws are moved up and down perhaps 100 times a minute, whilst the log is gradually forced against their teeth. By this method a thick heavy log is soon cut up into planks from a quarter of an inch to any other thickness, and little or no waste of timber is occasioned. Steam power is used to drive the saws, and from the rapidity of their action the noise in a saw-mill is truly deafening.

Circular saws are often used instead of the upright, and they are made by cutting out teeth from a circular piece of thin steel. This saw-plate is fixed on a spindle, and placed on a strong frame. The timber to be sawn is forced against the plate, which is driven round by steam power at the rate of 500 or 1,000 times per minute. By this means one piece at a time is sawn off very quickly.

Veneers, which are exceedingly thin pieces of wood, are produced in this manner. They are made from ornamental woods, as mahogany, rosewood, maple, walnut, &c., and are intended to cover a common wood so as to hide it, and make the article appear as if entirely made of the best wood. This is done by glueing the veneer carefully on the inferior timber; and if this be neatly done, the most practised eye can scarcely detect a joint. By such methods simple folks are often taken in when buying furniture, and only find out, years afterwards, the deception that has been practised on them.

When timber has been cut, it requires planing, which is now chiefly done by machinery. Mouldings, window frames, and many other house matters are thus manufactured, in place of by hand, as used to be the case.

So far we have occupied this chapter in describing what we shall call the "raw material" of our houses. Many other matters, however, are required, such as sheet-lead and zinc, water-pipes of iron and lead, nails, saws, glass for windows, &c., of which we have already spoken in the chapters preceding this (see those on "Metals," and the "Glass" trades), whilst others, as slates, tiles, &c., we shall defer until we describe the trades producing and using them. We now proceed to detail the trades followed in house building, &c.

THE BUILDER.

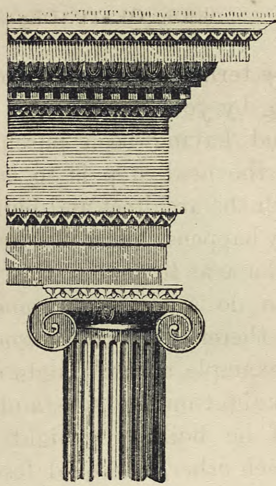
If we were to include all the duties which fall to the lot of the builder, we should have to consider him more or less as made up of some ten or twenty trades; for it belongs to him to see after every trade involved in erecting and completing a building. This, however, we shall not do, because most of these trades we shall consider under separate heads. We shall therefore deal with the builder in an every-day rather than in a professional point of view; and the building of a *house* will be the only branch of his business that will fall under our notice for the same reasons.

The first step in house building is the choice of the ground, for on this will depend the letting of the houses to be built on it. So many matters might be mentioned here that we cannot speak of them all; and not only so, but near large towns, where many people reside, it is often impossible to choose ground that would be desirable in all respects. The builder, however, bears in mind that the soil should be dry, easily drained, composed of gravel if possible, or, if not, of some substance which does not hold water. For this reason a clay soil, though good for the builder, because he can make bricks of it, is bad for health, because it is always damp; and where clay extends over a large surface, fogs and damp air are always great evils.

If the ground be bought entirely, it is then called freehold, and belongs for ever to the purchaser if he does not sell it, or is forced to do so on account of any great public work, such as a railway passing through it. Then the company must get power from Parliament to compel the man to sell it. But houses are more usually built on leasehold ground, which is let to the builder for 100 years, he paying a sum every year, called a ground rent. Of course, as men do not now usually live a hundred years, no one can hold the houses he thus builds for the whole length of the term, but he can leave them by will to his friends; and should they live longer than the expiration of the 100 years, the houses cease to be theirs, and become the property of the person's heirs who first leased or let the ground. Hence our young friends will learn the difference between a "freehold" and "leasehold estate," when they see such named in the newspapers, or on boards in fields, which are to let. A "copyhold" is a very long leased ground or estate; occasionally, indeed, it extends to 999 years, a length of time which even Methuselah himself might have considered "as good as a freehold." We have taken a little space to describe these terms, as we have often been asked their meaning by young folks.

The ground having been purchased on one of these terms, the next step is to lay it out, and in this duty both the architect and builder are engaged. It very rarely happens that a plot or piece of ground is of such a shape as to render this an easy matter, or at least to do so without some portion being wasted; and therefore much judgment is required. Suppose, for example, a man bought a plot of ground which was straight on one side, and curved on the opposite. If he built a straight row of houses parallel to each other, he would lose all the curved or circular part on one side. If, however, he built one side straight, and the other of a crescent or half-moon form, he could get more houses on to his land, and so get a larger amount of rent. Sometimes houses have to be built of different sizes, so as to suit the ground or neighbourhood. These and many other such matters are settled before the ground is laid out.

We do not intend to enter into any description of the different styles of architecture, either ancient or modern. At the present day it is really a question if any building is ever erected which has any pretension to a style complete in itself. Our young friends will scarcely understand us if we speak of Assyrian, Egyptian, Grecian, Roman, Gothic, Mediæval, Renaissance, and a host of other "styles," many of which are not even understood by persons who



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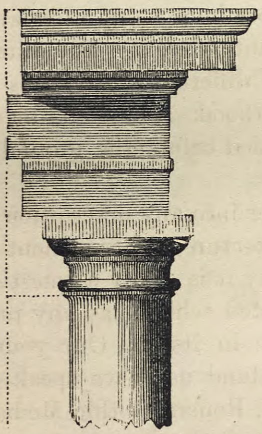

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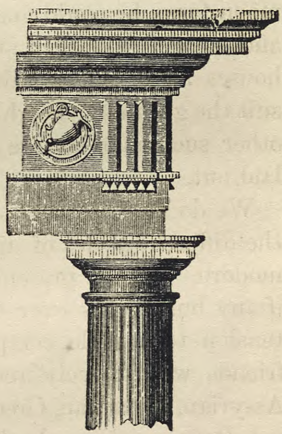
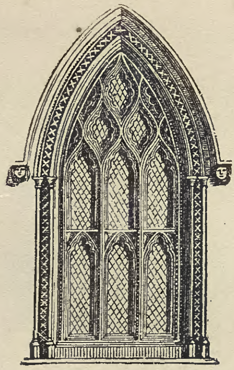
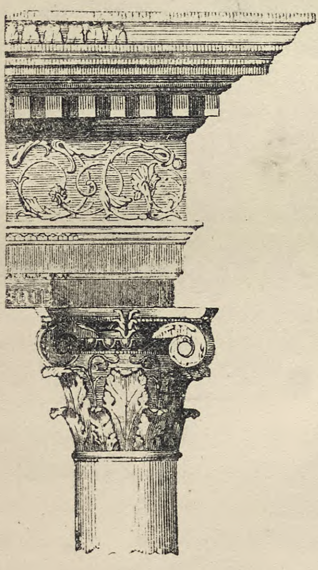


THE DORIC.

PLATE 17.—ORDERS OR STYLES IN ARCHITECTURE, p. 288.



GOTHIC WINDOW.



THE COMPOSITE.

THE CORINTHIAN.

PLATE 18.—ORDERS OR STYLES IN ARCHITECTURE, p. 288.

profess "to know all about them." We shall leave our young readers to acquire both the knowledge and taste in these matters as they grow older, and now simply commence, in imagination, the building of a house such as most of them live in; and if in after-years they have both the means and the will, they will no doubt learn all they require in a very short time, by aid of a competent architect.

A plan having been agreed on as to the way the ground is to be built on—that is, "laid out"—it is drawn on paper to scale; or, in other words, the actual size of the house, whether of height, depth, and breadth, together with the same measurements in respect to the outhouses, garden, &c., is represented on paper, the scale being at the rate, say, of an inch to each foot, or six feet, of the actual size. This plan is intended as a guide for the foreman, or, as he is sometimes styled, "the clerk of the works." The builder is not left to decide entirely on such things of his own will, for he is compelled by the law of the land to do so after having informed the "district surveyor," whose business it is to see that the building is erected in a way which will be safe and healthful to the persons who may afterwards live in it.

Laying the foundation is the first step; but before this is done the earth has to be excavated or dug out. Occasionally the foundation of a house is formed of concrete—that is, a mixture of pebbles, lime, and cement, the object of which is to give strength and firmness, and also to keep the house dry.

The bricks are then laid in courses on the concrete, and this introduces us to the trade of the "Bricklayer."

But, before speaking of this, we must say a few words about the drains of the house. These are very important, because through them all the "waste" of the house, as dirty water, and many offensive matters, are carried away. When we were young these were allowed to accumulate in large pools under the houses; now, however, in all our large towns such matters are carried off by the public "sewers." These are drains dug in the centre of streets, and sometimes they are very large. There is one in London which is so big that it would admit a locomotive engine, chimney and all, to go through it; and they are made to vary in size according as the neighbourhood is very large or distant from the place where the whole of these drains meet together. Of late years London has been completely drained, and the expense has been no less than four millions of pounds. This seems a large sum, but it is a trifle when we consider how much it has improved the health of that great city, and saved hundreds, if not thousands, of valuable lives. We have spoken somewhat largely on this subject, because we cannot too strongly impress on our young friends the necessity of taking care of health. It is God's best gift to man, so far as life here is concerned, and, as such, we should prize and take care of it.

We may now leave the "Builder" as a separate trade, and speak of those whose aid he cannot do without.

THE BRICKLAYER.

We have already described, at page 275, the general method of making bricks: we may here state, however, that various names are given to different kinds, according to their quality or the purpose to which they are to be applied. The bricks used to build our houses are "place" and "stock." "Red bricks" get their name from the colour that the earth of which they are made affords them, and these are very common in some of our northern towns, where the clay contains much iron. "Marl" bricks have a yellow colour, and they are used to face the place and stock kind, because they present a much better appearance. Some kinds used for this purpose are nearly white, and these are frequently used in building churches and other buildings in which stone and brick are used together. "Cutting bricks" are used for door and window arches.

Formerly, bricks used to be made solid, but now they are manufactured full of small holes, which has the advantage of making the brick much lighter and yet does not materially lessen the strength. The bricks used for paving yards, &c., are called Dutch or Flemish bricks.

In laying bricks they are placed with the end of one to the side of another, and this tends to bind them together better than if they were placed side by side. This our young friends may soon learn by trying the experiment with common bricks used as toys by children. One side of each brick is covered with mortar by means of a "trowel"—which is a flat plate of steel having a conical shape, and fitted to a handle—and they are then put together in "courses"—that is, in one level line—and over this another one, until the wall is built sufficiently high. The "courses" of bricks in a house, wall, &c., may be easily seen, as included between each long straight line of mortar running from end to end of the building, and enclosing one brick in depth.

When an arch has to be built, as over a door, window, or other place, a circular or wooden frame is first made, and on this the bricks are placed *edgeways* in one course. The next course is so arranged as that each brick shall overlay half of that beneath it; and thus, when the arch is complete, they all act as wedges, one with the other; and actually, *within certain limits*, the more such an arch is weighted the safer it becomes. If, however, such a weight be put upon it as will crush the bricks, or drive away the sides of the arch, then it will be destroyed. It is because of this strength of an arch that the top brickwork of windows is so made.

When we say that a wall is a brick thick we mean that its thickness equals the *length* of a brick. If two bricks thick, then it is equal in thickness to the length of two bricks, and so on. The lower parts of buildings are always made thicker in the brickwork than the upper, because they have to sustain the weight of the whole; and we thus find that outer walls of the attics of houses are generally thinner than the walls at the foundation. The wall that divides one house from another is called a "party-wall," and on its strength often depends whether or no a "fire" extends from one house to another, when that awful event takes place in a building.

The bricklayer is paid for his work at the rate of so much a rood or pole, the latter being a surface of $16\frac{1}{2}$ feet square and $1\frac{1}{2}$ brick thick. Bricks are generally about $9\frac{1}{2}$ inches long, $4\frac{1}{2}$ broad, and $3\frac{1}{2}$ deep, but they vary much in size.

In building houses scaffolding is used, and this is made by fixing poles in the ground, and tying shorter poles to these to bind them together. From these shorter poles others extend to the brickwork, where they rest, and across these poles boards are placed on which the bricklayer stands. The man who keeps him supplied with bricks and mortar is called a "hodman," from the "hod" in which he carries the materials up the ladder.

When the side and end walls of a house are built, they are finished with pieces of stone called "coping," and these, placed side by side, form the "parapet" of the house. A parapet not only makes the house look better, but it also prevents the rain, frost, &c., destroying the brickwork, which they would do were the latter left unprotected.

THE CARPENTER.

One of the most important trades connected with building is that of the carpenter, on whom devolves the making and fitting of all the wood-work in the house. With him we shall unite the trade of the joiner, who, however, is generally considered a higher class of workman.

At page 284 we have described the sawing of the wood into logs, planks, &c.; and have so far brought the "raw material" ready for the use of the carpenter. We must have a glance at his tools, whilst we describe his work. And the making of these tools has been already described in our chapter on "Metal Manufactures," (see the trades of "Cutler," "Saw-maker," "Nailer," &c.)

In the first place, the wood he uses must be sawn to a proper length, and this is generally done by the hand saw, which has large teeth, and does its work roughly. When small pieces have to be cut, tenon saws that have fine teeth are used. Various sorts of planes are employed to make the surface of the wood smooth, and for this purpose a "bench" is always found in the carpenter's shop on which planing, &c., is performed. The wood is fixed against the head of a screw to hold it, and the carpenter, catching firm hold of the plane, drives its "iron" against the wood, removing at each time a portion which forms "shavings." Planes required to give a round or other curved surface, at the rounded end of stairs, panels of doors, &c., are called moulding planes, and the iron is made of the curve which in use will produce the proper shape on the wood.

Chisels are really small planes or knives, and they are used to cut off and to make smooth the ends of pieces of wood already planed, to remove portions, so that one piece may fit in or on another, and for similar purposes.

Nails, screws, and glue (see page 260), are employed to unite pieces of wood together, and all these materials we have already noticed in their manufacture. In putting in nails a hole is generally made in the wood by means of a brad-awl, which is a sharp-ended piece of steel wire fitted to a handle. A gimblet is employed to make holes for screws, and its end is twisted something like a cork-screw. In either case the object of using these instruments is to prevent the wood being split on introducing either nail or screw. Hammers of different sizes are employed to drive in nails, and the screw-driver is equally useful for driving in screws. Pincers, or the end of the hammer slightly split open, are used to remove nails from wood when they have become bent, or are not wanted.

The carpenter has several methods of joining pieces of wood together in a manner that the outsides shall appear level with each other, and the joint be strong. Such methods are called "mortising, "dovetailing," &c. Mortising is effected by cutting away a portion of one piece of wood, so as to make the "tenon," whilst in the other piece a corresponding hole is cut, called the "mortise," so that when the two pieces are placed together they shall fit completely. "Dovetailing" is a more complete way of doing the same thing; and in this plan a piece of a cone-like shape is cut out from one board, and in the other the wood is cut so as to afford a solid piece that will fit in the hole made in the former. This is done by chisels; and an illustration of the plan may be found at the sides of drawers, wooden chests, &c., in which the edges are so joined as to give the greatest strength without either piece projecting beyond its fellow.

We cannot afford space to follow all the different arts which the carpenter uses in fitting pieces of wood together, shaping them, &c. We may just give a glance at some of the matters which it falls to his lot to attend to.

First, the "joists" have to be sawn out at their ends and fitted into the wall of the building. They are generally made of rough timber about two inches in thickness, and serve to support the flooring of each storey. On the joists the flooring boards are fixed, and they are laid across the joists, and firmly nailed to them. The doors require panelling, fitting, and planing, and are hung on hinges fixed to the door posts. The handles and locks on the door are also fitted by the carpenter. Window-frames are now made by machinery, but fitting of them into the posts, and "hanging" them with weights, &c., falls to the work of the carpenter. He also makes the roof, the shapes of which are exceedingly numerous. The staircases, balusters, or "banisters," as they are more commonly called, cupboards, shelves, &c., are all the handiwork of our friend; and thus we see that he indeed holds a most important place in house-building.

In our early days we were exceedingly fond of carpentering, and we strongly advise our young friends to save their pocket-money to purchase a small tool-chest. They will find little or no difficulty in learning how to use the tools, if they will first visit a carpenter's or builder's shop; but as the joiner or carpenter is often at work in our houses, they may, by watching him, catch sufficient information to teach them all they require to know. We picked up all our knowledge this way, and in after-life, when pursuing science, saved many a pound, and had great pleasure, in making the woodwork of many instruments, and in some cases, of doing what the ordinary carpenter failed to understand from our description. Such an occupation prevents idleness, which, of all other faults, in young persons is the most detestable. It has been said that the devil tempts every man, but that the idle man tempts him. In any case, however, we have little doubt that all our sensible readers will agree that there is nothing better than to be well employed, and if we can render our amusements useful we gain the double end of pleasure and profit. A "boy's tool-chest" we therefore recommend to all our young readers, as amusing, useful, instructive; and even, as a teacher of those good habits—industry and perseverance.

THE PLASTERER AND WHITEWASHER.

One of the most necessary trades in the ornamental part of our dwellings is that of the plasterer, for without his aid we should have nothing but bare brick walls, which would look very ugly; and we could not cover them with the paper-hangings always found in decent houses.

His implements of trade consist chiefly of his trowels and a flat wooden tool with which he makes the plaster level. His materials are mortar, plaster of Paris, and various cements. The mortar is more carefully made than that used in bricklaying, and it is mixed with hair to make it stick together. In plastering our walls he dabs first a quantity of mortar on the walls, to make a kind of rough coating, and on this he lays a kind of cement, generally made of plaster of Paris and whiting. This cement he flattens with the wooden tool, and when dry, the surface is ready to receive paper-hangings.

Ceilings and partitions that divide rooms on the same floor are done in a different manner. Laths about an inch wide and a foot or two long, are nailed against the wood-work, and on these he casts the mortar, which, falling between the openings of the laths, readily adheres to them. When this first coat of mortar is dry, the plasterer adds that of the cement; and in the case of ceilings, the only remaining duty is that of whitewashing.

Ornaments are made by moulding different cements in proper moulds; and the ornaments, when dry, are fastened to the ceiling by means of a little wet plaster of Paris, which soon dries, and adheres very firmly.

Whitewash is simply whiting, in fine powder, mixed with water and a little size (see page 260), coloured with smalts, which, having a blue colour, give a clear bluish-white to the wash. This is applied by means of a broad brush, two or three coats being sometimes given.

Some washing is done by using slaked lime mixed with size. It is coarser work than whitewashing, and is chiefly done to outside walls, or those of buildings used as out-houses. Houses which have been visited by fever, the walls of hospitals, &c., are often limewashed to destroy any infection.

At the present time the outsides of brick houses are often covered with cement called "stucco." This cement is mixed with oil, and when well applied it gives all the appearance of stone to the surface. It readily takes a coat of paint, and this, if properly done, lasts a long time. A great number of houses in and near London, where stone is expensive, are done in this way, and the streets have thus a very handsome appearance given to them. The cement also keeps the house warmer, and protects the brickwork from the action of the air, rain, and frost.

THE PAINTER.

One of the most common methods of decorating the inside of a house is that of painting; in fact, so common is it that few of our young readers could imagine a house fit to live in unless it were painted. We have, however, seen many which were quite guiltless of the art. In fact, in former times the wood was generally left bare; and hence the fine old oak carvings and panellings that we see in castles, old houses, and other ancient buildings. We must remember, however, that in those days only the best kind of woods was used for building purposes; and even for flooring, deal and such woods were then unknown; and hence the necessity for painting had not arisen.

But paint is not only ornamental, it is highly useful, for it preserves wood from that decay which would soon arise were it left uncovered. The air and moisture of some climates, and the dryness of others, would soon destroy the doors, &c., of our modern houses; and thus paint of some kind becomes quite a necessary of civilized life. Hence the painter's trade is an important one in connection with house-building.

His tools are only brushes, putty-knives, scrapers, and paint pots; but with these he does a vast amount of work. His materials are very numerous, because he requires not only many colours, but also many materials to produce them.

Paint is made by mixing up the colouring substance with *boiled oil*, turpentine, &c. Boiled oil is that of linseed which has been boiled with *litharge*, an "oxide" or rust of lead. The effect of thus boiling linseed oil is to convert it into a kind of varnish which will "dry" when exposed to the air. Now, common oil will not do this, as we all know, and hence the use of "dryers" (preparations of lead), so much used by painters. Turpentine is a kind of spirit obtained from a species of fir, and largely sent to this country from America. It is used to dilute paints, or make them more liquid, and is largely employed in making varnishes.

The "colours" used by painters are very various. Lamp-black is produced by burning oils: bone-black by burning bones. White paints are made from white lead (see page 257), oxide of zinc, baryta, whiting, &c.; and "putty" is similarly made, only with very much less oil, it being a solid. Yellows are produced from yellow lead or massicot, chrome also a salt of lead, &c. Reds are obtained from ochre a kind of earth, red lead, crocus or oxide of tin, cinnabar and vermillion, which are both preparations of mercury, &c. Blues are afforded by cobalt, smalts, ultramarine, Prussian blue, &c.; browns, from various earths; greens, from mixtures of yellows and blues, also from verdigris, emerald green, and Scheele's green, all of which are preparations of copper.

Paints are made by grinding the "colour" with "boiled or drying oil." This is done on a flat stone by another of a conical shape, called a "muller," and by rubbing this on the colour and oil they are intimately mixed, and all lumps, &c., are removed. The proper colour is obtained by a judicious mixture of various colours until the proper shade is gained.

Paint is applied by brushes made of hair or bristles, of which the painter uses various sizes, according to the work that he has in hand. He first cleans off all dirt and dust by means of a large brush, stops up all holes with putty, and paints over these, and knots in the wood, with a little "turps," or turpentine, mixed with red lead.

He applies then the first coat, and when this is dry, he rubs it over with a piece of pumice-stone—a kind of lava—so as to render the surface smooth. He then carefully applies another coat, or sometimes even a third, the last being that which gives the finishing stroke to his work.

The business of a painter is very unhealthy, and hence the workmen mostly look pale and ailing. This arises from the substances they use; and for the same reason, a newly painted house is very injurious to health.

Of late years pine wood has been much used without being painted. It has a very nice grain, and this, when varnished over, presents a pretty appearance. Varnishes are made by dissolving resins, such as copal, animi, &c., in boiled oil and turpentine. These dissolve the resins, and when they dry, the grain of the wood looks very beautiful. Oak thus varnished is much admired in churches and public buildings, where it is largely used.

The painter often unites the business of stainer with his own. The art consists in staining wood with colours dissolved in spirits of wine or turpentine, and thus beech, birch, deal, &c., may be made to imitate oak, mahogany, and rosewood. After the wood has been stained and dried it is varnished over.

The grainer, which is another branch of the painter's trade, produces the appearance of oak, maple, mahogany, rosewood, &c., by using solutions of substances affording the same colours as the woods we have named, and applied on common deal. The "grain," or mark of the wood, is produced by drawing a comb over the solution whilst still wet, or by touching it with a camel-hair brush moistened with a little turpentine or spirits of wine. By such means almost any kind of wood may be imitated, and when the "graining" is dry it is varnished over, which preserves it from injury. It is by such means that the outside doors of our houses are grained or painted. Maple, of all other woods, may be excellently imitated, as can also walnut; and these imitations are frequently done on the wood-work of our parlours and drawing rooms, giving them a very elegant appearance.

Out-door painting, such as of palings, iron railings, stucco work, windows, &c., is a much coarser kind of work than that we have described, but it has the valuable effect of preserving metal, wooden, and stone objects, hence the frequent outside painting carried on in our large towns, where smoke, dust, and dirt soon spoil the appearance of our houses and shops.

Our young friends may possibly have thought that, as we have told them how painting in and out of houses is carried on, we might say a word how paint is to be removed from our clothes when we have allowed them to touch a newly painted surface. This we can easily do, for all we need is a liquid that will dissolve the paint; and for this purpose it is best to rub the soiled surface with spirits of turpentine, or benzole, a liquid much resembling the former. This should be done as soon as possible after the clothes have been accidentally painted; and the spirits should be applied with a piece of flannel or other woollen cloth, gently rubbing the place until the paint is removed. The reason why this should be done immediately is, that if the paint be long exposed to the air, it dries, and becomes insoluble. Again, never rub the paint off by means of your hand, or any other object, except as we have here directed, because by so doing the paint is rubbed or forced in rather than off, and so will, of course, become more difficult to remove even with the aid of the turpentine.

There are many kinds of painting, such as fresco, encaustic, &c., employed to decorate public buildings, but these are not trades, but professions, so far as their pursuit is concerned, and therefore we must omit their mention.

THE PAPER STAINER.

Most modern houses have the walls hung with paper on which various devices have been made in colours, and the trade of making such "papers" belongs to that of the paper stainer. We shall describe the manufacture of paper in a succeeding chapter, when we have to speak of books, printing, &c. Paper hangings are not only ornamental but also useful, for they prevent the passage of heat from our rooms, through being bad conductors of heat—a term we explained at page 2—and thus do not allow the walls to cool the air, which would in that case cause down-draughts, and render the apartment cold, damp, and uncomfortable.

Paper hangings are made in pieces, each of about twelve yards long, and they receive their name from the surface or colours they have been printed with.

"Satin" papers have a glossy surface; "flock" papers have a kind of nap, produced by cotton or woollen flock of various colours fixed on one side of the paper, and which produces a kind of velvet-like appearance. Washable paper hangings are produced by a peculiar method of preparing the colours with oil or varnish, so as to render them insoluble in water. Striped papers are those on which the pattern forms a stripe, and they are printed in a very similar manner to cotton cloth; and which we described under the head of the calico-printer in the first chapter.

The coloured pattern is printed on the paper in a variety of ways. When the pattern is simply painted on the paper, through small holes cut in metal sheets to form the pattern, this method is called *"stencilling;"* but the most usual plan is that of block printing, and this we shall proceed to describe.

The block consists of pieces of wood equal to the width of the paper which is to be printed, and on one side the pattern is cut out so as to stand in relief—that is, to project beyond the rest of the wood, and it is on this part that the colour is placed before it is transferred to the paper. It must be remembered that there must be one block for each colour, so that if a piece of paper have ten colours, ten different blocks must be used over every part of it to produce the complete pattern. The colours, which are of various kinds, mineral and vegetable, are mixed up with size and water, and spread each on separate wooden frames covered with leather or flannel.

The paper is stretched on a long bench, and the workman then takes a block, and pressing its cut or pattern surface on the frame containing the colour, afterwards presses it on the paper, which at once receives the colour, and becomes printed at that part. He does this at the rate of about two feet in length of the piece at a time, and so continues till the whole piece has received *one* colour. He then takes another block for another colour, and proceeds in the same manner until all the piece has received an additional one; and so he continues, using as many blocks as there are colours, until the piece is finished. The paper is first prepared by washing it over with size and whiting, if it is to have a white ground; or with colour, instead of whiting, if it is to have a coloured ground. The object of the size is to prevent the colours "running," that is, mixing with each other, which, if permitted, would spoil the work completely.

Such is the method of block printing, but of late years many kinds of papers used for ornamenting the walls of our houses are printed in an exactly similar method to that of calico printing, and to one kind of which we have already alluded.

In block printing the workman must be very careful to impress each block in exactly that spot at which each colour should be, and he is guided in this by four pins, one at each corner of the block. These may easily be detected by their marks, if our young friends examine a "piece" before it is used by the workman whose trade is that of,

THE PAPER HANGER.

When choice is made of a paper to cover the walls, the next business is that of fixing it, and this is done by the person whose trade we have named above. At each edge of the "piece" a margin is left, and this the paper hanger carefully cuts off. He then takes care so to cut up the "pieces" that the pattern of one shall correspond with that of another piece, for if that were not done, the paper would appear exceedingly unsightly on the walls. The length, &c., to be covered is also carefully measured, so that none shall be wasted.

To fix the paper on the walls paste is used, and it is made by boiling flour and water, to which a little alum has been added. The walls are generally brushed over with a little size and water, to assist in holding the paper. This is first stretched on a table, and its back or unprinted part is then well coated with paste. The "hanger" raises this to the top of the wall, and first presses it at that part where the ceiling and wall join. By means of a soft clean cloth he gently rubs down the whole piece, and thus drives all air-bubbles away. Having covered the whole height of the wall to the width of the piece, he adds another, so as to join it at the side in a manner that their patterns run continuously in the width-way of the wall, and thus he proceeds until the whole room is "papered."

Sometimes a border is used to cover the edge of the paper where the ceiling or flooring joins the wall. The "border" is merely a narrow strip of paper printed with a device corresponding in colour and pattern with the paper hanging, and pasted horizontally on it. At times a gilt or other moulding is used, the object being the same as that intended in employing the border.

THE GLAZIER AND PLUMBER.

These two trades are generally carried on by the same person, and we shall therefore include them under one head.

The business of the glazier is that of fitting glass into the sashes of our windows. In former times mica or talc—a mineral substance which is transparent—horn, and many other materials, were used in place of glass; but at a still earlier period, as in the days of the Romans, Greeks, and Egyptians, even that plan was unknown, and so the windows of the houses, whether in the side or roof, were left open in the day time, and covered with a board or shutter at night. That plan was certainly not so inconvenient to them as it would be with us, because the windows needed not to be closed so continually to keep out wet and cold as we must do in our climate. Indeed, in some parts of Egypt it never rains; but the inhabitants have to put up with a worse nuisance in the shape of clouds of fine dust.

In the chapter on the manufacture of glass and pottery we have already explained how window, plate, and stained glass are produced, and shall refer our readers to it for information on the subject. The glazier receives the glass in crates, and the sheets have, except in the case of plate glass, a round edge; care must therefore be taken in cutting the sheet, to do so in a manner that shall prevent waste. The cutting diamond, described at page 202, is used for the purpose.

The glass having been cut to the proper size for each pane, is placed in the frame, and held by two or three small brads or nails. Putty, made by mixing oil and whiting together, is then forced in by a flat knife called a putty knife. The glass is thus held secure, and prevented from falling out.

The stained windows of churches and other buildings, together with the glass used in old-fashioned cottage windows, are made by fitting the pieces of glass in small frames made of thin sheet-lead, which hold the glass in a similar manner to that which is done by the fingers. When the glass has been fitted in, the lead is pinched together, and so for a time firmly holds it. But wind and weather soon open out these lead joins, and thus draughts are sent into the room. To prevent this, and to make our sashes quite wind and water-tight, putty is always now used, except for church stained windows and similar ornamental purposes.

The business of the *plumber* is that of making joints in pipes, sheets of lead for roofing, &c. He does this by cutting the edges of either the sheet or pipe so that they may lap on each other. He then applies melted lead or solder, and in the case of pipes, holds and moulds it by means of a piece of old carpet, to prevent the heat passing to his hands. The "iron" is heated nearly red-hot, and then pressed against the joint, to mould it into a neat form, and to close up any holes, so that it may be rendered completely water-tight. Water cisterns, &c., of both lead and zinc, are thus made; spouts, eaves of houses, and the channels or gutters on our roofs, are similarly fitted in their places.

THE SLATER, TILER, &c.

We have just spoken of the roofs of our houses, and we must describe how they are made, and also say a few words about chimney pots, &c. For this purpose we must deal with the trades of the slater and tiler.

Slates are obtained from many parts of the west coasts of our country, as Westmoreland, Wales, &c. The slate occurs in immense masses, forming, in fact, mountains or portions of them. The slate has the advantage of being readily split into flat plates, as our young readers well know from their experience at school; but perhaps they are not aware that the material may be so divided that large sheets can be produced which would require no less than thirty-two to make one inch in thickness. Those used for roofing purposes are, however, generally not less than about one-quarter of an inch in thickness.

A roof which is to be slated is first prepared by nailing on the rafters thin boards, and on these the slates rest. The latter are so arranged that those descending from the top of the roof shall pass under those immediately above and resting on them, and they are kept in their places by a nail or two driven in at a little distance from their inner edge. The object of thus arranging the slates is that of causing the rain to run off without getting between them, and if such were not done, of course the water would soon run into the house and spoil the ceiling.

Tiles are made of earth, in a very similar way to the method of making bricks, already described in the early part of this chapter. They are fixed in a similar manner, and for the same reasons as slates, and thus water is carried into the gutters of our roofs, and at last passes off by the spout or pipe to the drain at the lower part of the house.

Chimney pots are made of various materials, such as tile-earth, stucco, zinc, &c. Their object is to afford a free vent to the smoke passing up the chimney, and carry it completely off the roof. Various contrivances have been made for the purpose of preventing chimneys smoking, and chimney pots, cowls, &c., of all kinds have been invented for this object; but we cannot stop to describe these, for two reasons, first, because they are too numerous, and secondly, because we think such are generally of no benefit, and do not answer the purpose for which they are intended.

UPHOLSTERER, CABINET-MAKER, &c.

Under this head we must include several trades which have to do with the furnishing of our houses, for they are all, generally speaking, carried on by the same person, and for the same purpose—that of making our houses fit to live in as homes. How many matters do we require for this purpose! There are our chairs, sofas, tables, beds, mattresses, bedsteads, wash stands, boxes, drawers, side-boards, and wardrobes, with a number of other minor pieces of furniture, which our space would fail us to even mention. All the articles we call furniture, so far as they are made of wood, have chiefly to undergo the same processes of sawing, planing, &c., which we have already described in the trades of the carpenter and joiner; whilst the woods used have been named when we spoke of the business of the timber dealer, in the early part of this chapter. We there mentioned what veneers were used for, and how that method of using fine grained wood to cover the inferior sort was often employed to deceive unwary persons.

The round parts of our furniture, such as legs of chairs, tables, bedsteads, &c., are made by turning the wood in a lathe, and as it goes rapidly round a steel tool is pressed against it, it acting somewhat after the fashion both of a plane and chisel. The art of joining parts of our furniture together requires greater skill than we generally find in the carpenter, and hence has given rise to the trade of the cabinet-maker, to whom we are indebted for all the mahogany, rosewood, walnut, and other fine wood articles, which are the furniture of our houses.

The *French-polisher* makes these fine woods look finer still, for he coats them with a polish which brings out all the beauty of the grain of the wood employed. He uses a solution of copal and other gums in spirits, and he rubs this, which is a fine kind of varnish, on the wood by means of a little cotton wool until they present the well-known polish. Naphtha polish and other kinds are used for inferior sorts of work, and common or rough-made articles. It is the business of the *Upholsterer* to put the seating in chairs, sofas, &c., and he uses wool or horse hair to stuff them with; whilst cloth woven out of horse hair, or cloth made of silk and wool, is used to cover the stuffing, and form the surface on which we sit. Beds are made by sewing together strips or pieces of linen or cotton cloth made on purpose, and called "ticking." These are then filled with feathers obtained from poultry, geese, and other birds. The finest kinds are those made of eider down, which is obtained from the eider duck, a bird common in the northern portions of Europe and America. It is obtained by robbing the nests of the bird, who lines them with this beautiful material for the purpose of keeping her young warm; and as she thus loses it, she plucks more from her bosom, until sometimes as much as half a pound has been obtained from one bird.

The commoner sorts of beds are stuffed with cotton flock—a waste of which we spoke when describing the manufacture of cotton in the first chapter. Another curious source for stuffing beds, mattresses, chairs, sofas, &c., is old carpets. These are bought in large quantities and torn to pieces in a "devil," which we mentioned in speaking of the manufacture of common woollen cloth for coats. Sea-weed, collected on the coast of Holland and other places, and sold here under the name of alva, is used for bedding intended for being sold cheap.

Looking-glasses we have already spoken of in our chapter on the glass manufacture, with other articles of glass and pottery used in our houses, such as tumblers, plates, jugs, cups and saucers, wine-glasses, &c. And the chapter on metals will afford our young friends information respecting many articles of domestic use which are made of metal.

There is one trade which we may here mention—it is that of the *Cooper*—whose productions are of great value to the household, because on him we depend for tubs, and a variety of other useful articles for holding liquids and solids. A cask consists of three essential parts—the heads, staves, and hoops; and perhaps our young readers are not aware that when a cask is cut in half, it makes two excellent tubs for washing and other purposes. Generally speaking, the staves and heads of casks and tubs are made of oak, because that wood is the most durable, and expands or contracts least in the presence or absence of moisture. The staves or ribs of a tub or cask are those pieces of wood which form the sides. They are made wider in the middle than at the ends, and they are shaped by a peculiar kind of plane made for the purpose. Inside the narrow end of each stave, and at an inch or so from its extremity, a kind of notch is cut, and when all the staves are put together, the notch in each forms a kind of ring, and it is into this that the head of the cask or tub is placed. When this is done, the hoops are put on, the widest being forced on first, and so each in succession until the narrowest, which forms the end rim of the outside of the vessel, is put into its place. A cask or tub when thus finished often leaks at first, but after a time, when it is filled with water, the wood swells and soon fills up any open spaces between the staves. Old wine and brandy casks are converted into water butts by simply taking out the head and fastening up the bung-hole. They are generally covered with pitch inside, to preserve them from the action of the water, and sometimes they are charred by lighting a fire within them. As it burns it converts the internal surface into charcoal to a slight depth, and as this is indestructible by air or water, the cask lasts much longer, and the water it contains is kept sweet.

We have thus described the chief of those trades which supply us with the movable articles of furniture in our houses. The manufacture of curtains and bed furniture has been more or less described in our articles on the Wool and Cotton trades. But there are two articles to which we must pay more than a passing attention. They are, carpets and floorcloths, which are not only ornamental but useful.

CARPET AND FLOOR-CLOTH MAKERS.

We have united these two trades for two reasons, the first being that both articles are used for similar purposes, and the second is, that an old carpet, when all its pattern is worn away, makes an excellent foundation on which to make a floor-cloth.

There are many kinds of carpets, such as Brussels, Tapestry, Kidderminster, Turkey, &c. The Brussels carpets are made of hemp yarn on one side, and the pattern is produced by woollen thread, and appears at the surface. Tapestry carpets are only a variety of Brussels, and are so called because the pattern is generally an imitation of tapestry work. Kidderminster are made entirely of wool, or, at least, used to be; and all these are woven in a loom which resembles in *some* respects that used in manufacturing cotton, with this exception, however, that a peculiar arrangement is employed by which the pattern is produced on the surface. The loom was invented by M. Jacquard, and a most ingenious affair it is. We fear that we can hardly explain its construction to our young friends so that they will be able to understand us; but we will try. The lower part of the loom is very similar to that described in our first chapter, at page 14; but overhead is a kind of frame containing a large number of pieces of cardboard pierced with small holes, which correspond precisely with the pattern to be worked on the carpet. These holes are intended to act on strings attached to the weft of the carpet, and they do so by indirectly raising or lowering the threads of the weft so as to allow the thread on the shuttle, or warp, to pass over or under any number of them instead of between, all at once, as is done in the common calico weaving loom. Now in this only one shuttle and one coloured yarn or thread is worked; but in the Jacquard loom several shuttles, loaded with different coloured threads, may be employed, and so patterns of any kind may be produced, according to the taste of the maker or the fancies of his customers. Such carpets are made in many parts of our kingdom; and we may here add that Paisley shawls, so much admired by the ladies, are woven in an exactly similar manner.

Turkey carpets are made in squares, and not in one continuous length, like those we have described. They are produced in various parts of Syria or Turkey in Asia. Persian carpets are highly prized, but are very expensive, and only found in the houses of rich people. Stair carpets are manufactured in a similar way to the Brussels kind, but are narrower. Of late years these have been made of jute, a kind of hemp got from India. It receives a very good dye, and makes a cheap and durable carpet.

Cocoa-nut matting, used in halls, &c., is made from the husk which surrounds the common cocoa-nut. When this fibre is twisted, it forms what is called "coir-yarn," and this is afterwards woven into the cloth or matting. Door-mats are made of hemp or jute; but of late years others made of india rubber have come much into fashion. We have spoken of these and "kamptulicon"—a floor-cloth made of india rubber and cork, and also of "linoleum—" in the chapter on Gutta Percha and India Rubber manufactures.

Floor-cloth is simply a hempen cloth, or carpet painted over, and printed with any desired pattern in colours. The cloth is hung on poles, and a drying paint applied on its surface after that has been coated with size. Wooden blocks are used to print the pattern, which is done in a precisely similar manner to that described as followed in printing paper hangings, only colours ground in boiled oil and turpentine or varnish are used, because a floor-cloth must stand washing. They are very durable, easily cleaned with soap and water, and so are in use in most of our houses, for covering staircases, kitchen floors, and other places where much rubbing or rough usage may be expected.

Some handsome kinds of ornamental work, for flooring, are occasionally employed; and they are made of small pieces of wood, stone, glass, &c., united together in such a manner as to form beautiful patterns. This is called "Mosaic work," and in ancient times it was largely used. Specimens of this work have been obtained from Pompeii, and have also been discovered in many parts of this kingdom at some distance underground. Ornamental tiles are much used for similar purposes, and in the Houses of Parliament many of the floors have been made of them. They look very handsome, and are exceedingly durable. Their mode of manufacture is similar to that described when we spoke of the trade of the Potter. Parquetry flooring is made of pieces of wood fitted together so as to form any desired pattern.

CHAPTER IX.

TRADES CONNECTED WITH TRAVELLING, ETC.

We now turn to a very interesting subject—namely, the means we have of travelling from place to place, and of conveying goods, &c. And here we may make a few remarks on the value of exercise, especially for young persons. We have travelled in every part of our country, and whilst doing so have constantly noticed that persons who have to get their living in the open air, either by working, walking, or riding, have always the enjoyment of better health than those living in towns, and whose occupation of necessity keeps them in-doors. The former possess ruddy, healthy-looking faces, strong muscles and limbs, and enjoy their food heartily; whilst the pale faces seen in our factories and other close places, and in the towns, where such are found, tell the tale of illness, premature old age, and death. For our own part, we are always delighted to see young persons actively enjoying themselves in the open air; and the reason of our benefiting by out-of-door exercise is this,—first, we breathe a greater quantity of better air, because the exercise stimulates our lungs; this again increases our appetite, by more rapidly burning away our food in a manner we have already explained in our remarks at the early part of the chapter devoted to food-trades; and lastly, the more rapidly and effectively the food is thus consumed, the heartier and healthier do we become, and the fitter are we for every duty or pleasure of daily life. The two best "doctors" are *air* and *exercise;* and abundance of these entirely prevents the necessity of medicine, except in very special circumstances, over which we can rarely exercise much control. We have generally noticed that the most *useful* men are those who have the healthiest bodies; and further, those who in early life have neglected their health in long study and want of out-door exercise, shine in after-life for a time, but generally die comparatively young, because their bodies are not strong enough for their minds. The old saying, *Mens sana in corpore sano*—that is, a sound mind in a sound or healthy body—should be constantly kept in remembrance by our young friends; and such out-door amusement as leaping, running, &c., and walks into the country, are just the means by which the old saying may be practically observed. We speak from long experience when we say, that after a day's rest we can do twice as much hard thinking and writing—especially on scientific subjects—in three or four hours, as we can in a whole day after three or four days' constant labour in these pursuits. We do not, however, recommend neglect of proper duties for the purpose of relaxation. No. Lessons first and play afterwards. Neither is to be neglected, but each to be kept in its proper place.

And now to our subject. In the early history of man we find that *walking* was almost the only method of getting from one place to another; whilst sick or infirm persons, with goods, &c., were conveyed on the backs of animals. The children of Israel *walked* for forty years in the wilderness, for the same reason that always happens in wild countries—namely, that there were no roads. Even in our own day this is almost the only method of travelling in places newly discovered; and it is by such means that Canada, the Arctic regions, Western America, Africa, Australia, have been explored and opened out as places fit for colonists to take up their abode in.

If we take up this idea we shall find that the question of *roads* is the most important of all the subjects in our chapter, and, directly or indirectly, has produced all the trades we shall have to describe. There are only three kinds of roads, and they are the *common land;* the *water roads,* as of rivers and canals; and lastly, the *railroad*—the newest, and now, perhaps, the most useful of all. We shall describe the numerous occupations which have been produced, and are required in connection with these means of travelling.

We shall commence with those trades which are connected with common road conveyances; and here we must remark that road-making is, after all, to some extent, a trade. Nothing is of more importance to the prosperity of any place than a good road; and by a good road we mean one over which horses, carriages, men, and even sheep and cattle can travel easily.

In large towns the roads are always divided into footpaths and the carriage or roadway. The former are reserved for the use of persons walking, whilst the "road" or carriage-way is for vehicles, &c. The footway is generally covered with flagstones—that is, stone obtained in flat pieces, of various sizes, from Portland and other places—and edged with a narrow piece of granite, which, being hard, does not wear away so rapidly. For this reason granite is sometimes used as pavement; and in many places we have seen a kind of slate employed for the same purpose. But this and granite have the objection of wearing so smoothly as to become slippery, and hence exceedingly dangerous in walking on. To some extent this is prevented by "chipping" the surface of the stone.

The road or carriage-way is made after several different plans, according to the amount of traffic likely to pass over it. In country places gravel and sand are used; and in such cases we rarely see a pathway. From this circumstance, it is a very common occurrence to find countrymen walking on the roadway when they visit a town. They have been so long used to the absence of paths, that they fail to use them even when before their eyes. But roads near to large towns are "Macadamized,"—a method so called after the name of the inventor. Such a road is made in the following manner:—The "bottom" or "ground" is composed of hard rubbish, such as broken pots, pans, bricks, &c., raised higher in the middle of the road than at its sides; so that when the "metal" is put on the surface, from its rise in the middle, it may permit all the water to run towards the gutters on each side. The "metal," as it is called, consists of pieces of granite, or other hard rock, abundant in Scotland, Wales, &c. Each piece is of about the size of a small apple; and as the carriages, carts, &c., pass over it the pieces are forced together—the minute dust ground thus from the surface of each soon forming a kind of cement, which binds all together in a firm, hard mass. Nearly every road *leading out* of, but not in London, is thus made.

In large cities, however, such a road would be soon cut to pieces, and therefore small blocks of granite are used, which are much of the shape and size of common bricks. These are laid crossways on the roadway, and are set in courses, much after the same style as that followed by the bricklayer. But first of all a foundation is made, by mixing sand, pebbles, and lime together, on which the granite is afterwards to be laid. As rows of this are laid down, the blocks are forced together by beating them with heavy blocks of wood, and then a mixture of sand, lime, and water is strewn over, which cements the whole together. *Wood pavement* is made in a similar manner, only that blocks of wood are used in place of granite. Blocks of cast iron have been sometimes employed for the same purpose, their surfaces being roughened, however, so that the horses' hoofs may "hold," or catch hold of them. Burnt clay is also used; but now generally for foundations only.

When there is much traffic or business on a road, a kind of stone tramway is laid—that is, blocks of granite are placed lengthways on the road, at a distance from each other equal to that of the wheels of a waggon. By this plan the draught or drawing power of the horses required is lessened, and, in fact, a kind of stone railway is made.

On each side of a road openings are made into drains or sewers, to which the rain water is conveyed from the roads and through the gutters at the sides. It is of importance to keep all roads dry, and therefore, when any part is worn away, it is at once repaired—that is, it is raised by fresh "metal" to the same level as the surrounding parts.

Having thus described the methods followed in road-making, we shall speak of trades connected with the building and drawing of carriages, &c.

THE COACH-BUILDER.

There are so many kinds of conveyances that, were we to attempt to describe them all, we might easily whole rapidly. [illegible] similar manner, [illegible] as [illegible] [illegible] [illegible] [illegible] [illegible] clay [illegible] [illegible] [illegible].

When there is much [illegible] a kind of stone [illegible] graphs are placed [illegible] into each other [illegible] of the wheel. [illegible] the plan, the [illegible] of the horses [illegible] a kind of [illegible].

Our canals [illegible] deep ditches in which the rain water is [illegible] from the roads and through the [illegible] of the [illegible] then [illegible] and part is [illegible] the [illegible] levels and surrounding parts.

There [illegible] the method followed in road-making, we shall speak of [illegible] connected with the building [illegible] of [illegible], &c.

[illegible]

There are many kinds of [illegible] we [illegible] to [illegible] all we might easily

PLATE 19.—COACHES OF THE TIME OF QUEEN ANNE, p. 327.

fill the best part of our little volume. There is, for example, the cart, waggon, &c., used for conveying heavy loads; the gig, pony-chaise, landau, phaeton, brougham, cab, omnibus, coach, &c., which are used chiefly for conveying human beings; but, with the exception of strength and shape, they really do not differ very much from each other. For instance, if for a single horse, they have shafts, or for two a pole is fixed to which the horses are attached. Then, again, they each have wheels, springs, axletrees, &c., so that we may safely choose one as a type or specimen of the whole. We shall therefore select that which requires the most work to fit it for use; and a gentleman's private carriage will give us, in its description, an opportunity of referring to all the trades connected with coach-building.

A "carriage" is composed of two parts—namely, the "body," which is that in which we sit, and the "carriage," or that portion which serves as the framework on which the body rests by means of springs, and it includes the perch, axletrees, wheels, &c.

The body is made of any hard wood, elm being used for carts, waggons, &c., requiring great strength; and mahogany, cedar, pine, &c., are employed for the better kind of vehicles. In making a carriage the whole is first sketched out on paper, according to some chosen design, and this forms the pattern or guide which the builder follows. The different parts of the body are made by the usual process of sawing, planing, &c., which we have mentioned when speaking of the trades of the carpenter and joiner, in the previous chapter. But sometimes the wood requires to be bent into a curved shape, and this is effected by "steaming" it. This is done by enclosing the part in a chest into which steam is admitted, and the heat and moisture soon so far softens the wood as to permit of its being bent into any required form.

The leather cover which forms the upper part of the carriage is put on by moistening the skin with water, and pressing and forcing it tightly on to the wooden frame, much after the manner we have already described as followed by tanners in preparing morocco leather (see Chapter I.); when dry it adheres completely on the wood, and so forms a water-tight covering. To conceal the rough edges of the leather a beading of brass rod is fastened on round the ends of the skin.

The next business is to paint and varnish the body. This is done by the *coach painter* applying repeated coats of paint successively on each other as they dry; and removing all roughness by rubbing the surfaces with pumice-stone. The next process is to varnish over the painted surface, and this is done with copal varnish, and a beautiful polish is produced. We must simply state that, in reference to the "fittings," with the seating and stuffing of the inside of the carriage, several trades are employed. The *coach-plater*, *smith*, &c., supply the handles and metal work, the *coach-lace maker* the armlets, &c. Then there are the *coach-lamp maker*, *beader*, *carver*, and others—in fact, a trade to each of the numerous parts of which the body is composed, or by which it is ornamented and completed.

The "carriage" next deserves our attention. As we have already explained, it is that part on which the body rests. When only two wheels are attached to the vehicle, as in the gig, dog-cart, &c., the shafts are fixed to the body. They are two long pieces of tough wood projecting on each side, and serve to receive that portion of the harness by means of which the horse is attached, and draws the carriage. If four wheels are used, then they are connected by means of a long pole called a *perch*, which is attached to the framework that carries both the hind and fore-wheels, the latter being so arranged that they can turn in the perch in the same direction as the *pole* carried forward between the horses, whilst the hind-wheels are fixed, and must turn round in the same line as that in which the carriage travels. The fore-wheels are thus fixed, with the power of turning in any direction, so that the carriage may be permitted to go round corners, &c., which it could not do if they were arranged in the same manner as the hind-wheels.

The axletree is that portion of the "carriage" on which the wheels revolve. It passes crossways under the vehicle, and is generally made of iron. Its ends are pointed, so as to run into the centre of the nave of the wheels, and they are prevented from slipping off it by means of a pin run through the axletree at a short distance from its end. This, however, is an old method now rarely used in carriages, for at the present time the wheels are kept on the axle by means of "boxes," which are much more secure, the construction of which, however, we cannot describe on paper.

The *Wheelwright's* trade must now be described. A wheel consists of four parts—namely, the *nave*, the *spokes*, the *felloes*, and the *tyre*. The "nave" is that portion of the wheel which forms its central and solid part, and which fits on the axle, round which it revolves when the carriage is in motion. All round, and in holes in the nave, the "spokes" are fitted, and these pass on to the "felloes," which are those pieces of wood that form the outer rim; and they make, in small pieces fitted together, the circular part on which the tyre is fixed. The "tyre" is the metal ring which is the outermost part of the wheel, and that touches the roadway. The tyre is fitted on to the felloes in a very curious manner. It is made in a circular form, slightly smaller than the wooden rim of the wheel on the outside of the felloes. It is then made red-hot; and as nearly all bodies expand or get larger when heated, the tyre obeys the same law, and actually, in this condition, becomes larger than the wooden rim. In the red-hot state, then, it is forced on to the rim, and cold water is instantly thrown on to it, when it at once contracts, and binds the rim with enormous force, than which it again becomes smaller when cooled. It thus contracts or forces the felloes together, and so is as securely fastened on to this as if such had been done with screws: in fact, it rarely comes off until one part be broken. India rubber tyres, formed of rings of that material, are sometimes placed over the iron ones, and they are chiefly used for invalids, because they destroy all sound and jolting as the carriage passes over a rough roadway. Iron wheels, made out of wrought iron in every part, are sometimes used in place of the wooden kind we have just described; but they are chiefly employed in waggons, where great strength is needful: they are too heavy and noisy for light carriages.

We have yet to describe the springs on which the body of vehicles rests on the "carriage" or lower part. The springs are generally made of steel plates, not fixed solidly together, but so arranged that they may slip a short distance over each other, being secured by little pins from going too far. When speaking of steel in the chapter on Metal manufactures, we referred to its elasticity, or that quality by which, when once bent, it returns to its old shape; and when describing the making of swords, we noticed how the best steel kind may be bent almost double, and yet regain its old shape. Now, to some extent, this is just the quality required in coach springs, for the purpose of preventing that serious jolting occasioned as the carriage moves rapidly along. The springs break this jolting, and hence save the traveller a great amount of inconvenience and discomfort, not to say danger. Leather was used at one time, but steel is now almost universally employed. Springs have various names, as C springs, &c., all of which are given to them according to their shape or special use.

We have already stated that the essential parts of a carriage, cart, waggon, &c., are all alike, and differ chiefly in their strength, or the peculiar construction of the vehicle. We shall therefore content ourselves with what has been said, and now speak of the animals used to draw our conveyances, whether for goods or passengers. In many countries, and sometimes even in our own, oxen are employed for the purpose, but the pace is so slow and uncertain that they are rarely used. Asses and mules are more frequently employed; but, after all, the horse is to be considered as *the* beast of burden in all European countries. He is tractable, good tempered (unless badly used), sagacious, and even desirous of work. He can walk, trot, run, or gallop fast; and, if well kept, he can do more work than any other animal in drawing carriages. We cannot say anything further respecting him, and need not, because all our young readers know him well. But we must describe two trades that are required to fit him for the work to which he is generally put. They are those of the farrier and saddler.

The *Farrier* attends to the shoeing of the horse, but very frequently he is also his "doctor;" that is, he treats him when he is ill—for horses are, like ourselves, liable to many complaints. The horse's doctor is, however, generally called a veterinary surgeon, and there is near London a large hospital where the diseases of horses are studied and attended to. The shoeing of horses is required in places where the roads are hard, because the hoof of the horse is too soft to stand the wear to which it would be subjected if unprotected by a shoe. In many countries, however, shoeing is dispensed with, because the roads are soft. The shoe is made of a piece of soft iron, bent by hammering, whilst red-hot, into the shape of the horse's hoof; and holes are made, so that nails may be driven through into the hoof when the shoe is put on. It is thus prevented from being kicked or thrown off. The hoof is first cut by means of a sharp knife, to put it into a proper shape, and to remove such portions as have grown too much. For, like our nails, which the hoof resembles, it is constantly increasing in size.

Much care is required in fastening the shoe by means of the nails; for if one of the latter be driven in too far, the horse's foot may be seriously injured. This is called "pricking;" and carelessness in this respect has entirely spoiled many valuable horses, and made them lame for life.

The business of the *Saddler* or *Harness-maker* is that of making the various articles generally used for attaching horses or other animals to vehicles, and such articles as are used in horse-riding. They are numerous, and include saddles, collars, traces, reins, &c., the material which is used being leather. The tanning of skins, and the preparation of leather for such purposes we have already described, under the head of the "Tanner," &c., in the first chapter; and the business of the saddler &c., is that of cutting out, shaping, and sewing the material. The *Saddlers' Ironmonger* supplies bits, buckles, hooks, chains, &c., used for harness; and the method of making and plating such articles may be learned generally in our chapter on Trades connected with Metals.

We have only spoken at present of carriages, or other conveyances drawn by animals on common roads. We must not omit to mention that of late years the steam engine has been much employed in drawing heavy weights, in place of horses, between one part of a town and another, and between places some distance apart. When quite a lad we remember seeing an omnibus, invented by Mr. Hancock, driven by steam, and plying between the Angel, Islington, and the city of London. The noise and smell, however, were so great that these contrivances were soon laid aside, and even the traction engines which we have just named are only allowed to travel when they can do so without being likely to prove dangerous. The most difficult thing is to *guide* these machines, for horses possess an instinct which almost always enables them to find their way safely, even through narrow passages, as turnpike gates, and the like. Steam carriages on common roads, however, are simply guided by a lever, worked by a man, and acting on the fore-wheels of the vehicles. Now, as the man is generally some distance from the object to be passed, whilst the head of the horse attached to the carriage is usually close to it, the animal has by far the better chance of getting safely through or past an obstacle, if he have the entire use of his sight. Some years ago a somewhat laughable occurrence took place, which illustrates the difficulties of guiding the steam vehicle. One of these, guided by a man who accidentally let go the lever, was driven, passengers and all, with full force, into a large shop, much to the terror of the customers and lookers-on.

This subject leads us to that of railways, of which we shall next give a short description.

RAILROADS—THE CIVIL ENGINEER, &c.

So far we have described the methods of travelling on common roads. We must now speak, briefly however, of a very interesting subject—namely, that of railroads—which, as far as carrying passengers is concerned, is an invention of this century. For many years tramways have been employed for rendering the carriage of coals, &c., near mines, easy; but it was not till the Liverpool and Manchester Railway was opened, on the 15th of September, 1830, that the value of this method of travelling was discovered. Since that day railways have spread rapidly throughout every civilized country in the world; and as for our own country, its surface seems almost everywhere cut up with "lines," as railroads are frequently called.

The business of the *Civil Engineer*, although connected with many other matters, is now most specially so with railroad-making; and under this view alone, and for the purpose of explaining the construction of a railway, shall we consider it.

The first step is to choose the terminus, or last chief station, either way on the railroad; and this term is only applied to such stations as are of the greatest importance. Thus, Euston is the terminus of the London and North-Western line, Paddington that of the Great Western, and so on. Stations between these and other large stations simply receive the latter name; and when they are of minor importance, the term "intermediate" is also used.

Of course, we need not tell our young readers that it rarely happens to the engineer to find a country so even that the railway can be laid perfectly level on its surface. Generally speaking, valleys or hollows have to be filled up and crossed by *embankments*, hills have to be cut through by *cuttings* or by *tunnels*, streams crossed by *bridges*, and so on. Any railway presents some of these; but we may mention that, amongst bridges, the Britannia Tubular Bridge, which crosses the Menai Straits on

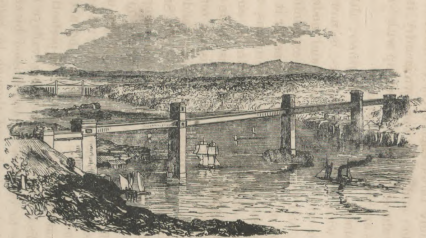


PLATE 20.—THE BRITANNIA TUBULAR BRIDGE, p. 336.

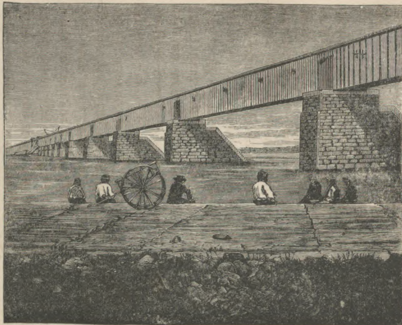


Plate 21.—The Victoria Bridge, Canada, p. 337.

the road to Holyhead, in Wales, and that splendid one, the Victoria Bridge, across the St. Lawrence, in Canada (see plates), both the work of the celebrated Stephenson, who with his father has done so much for the railway system;—these are two of the largest and most remarkable yet made.

In making a *cutting*, the earth which is removed generally serves to form an embankment, and the *gradients*, or rise and fall of the line, are so chosen that this plan may be carried out; for then great expense is saved in removing the earth. The men employed are called *navigators* or *navvies*, and they are paid, not by time, but by the quantity of work they perform. Bridges are made of wood, brick, and iron, the last being the material most used, because it is stronger, cheaper, and more durable than any other. The solid bars of cast, or hollow cells of wrought iron used to cross a road or stream are called *girders*, and these are sometimes of great size. The two bridges which we have just named are built on a different principle; they consist of long tubes or cells, through which the railway train passes on its journey, and they are now much used.

When the bed of the railway is formed, the next step is to level it and cover it with *ballast*. This may be broken stones, gravel, burnt clay, &c., the object being to obtain a tolerably level surface. On this ballast the *sleepers* are laid. They are pieces of timber either placed *across* the line, as on most of our railways, or lengthways, as seen on the Great

Western. This plan has been chosen by the celebrated Brunel, who was engineer of that line. On the sleepers the *rails* are laid, and these are made of wrought iron, after the method already explained at page 140. The rails are kept in their places by *chairs*, which are pieces of cast iron, having a hollow to receive the rail, and shoulders at each side through which nails are driven into the sleepers. It is on these *chairs* remaining in their places, and so keeping the *gauge* of the line, that the safety of travelling essentially depends. By the term *gauge*, we mean the distance between a pair of rails. The *narrow gauge* railways, as the London and North-Western, and nearly every other in the kingdom, have their rails 4 feet 8½ inches apart, whilst the *broad gauge*, as the Great Western, have the rails 7 feet apart. Between each pair of rails, on all railways, there is what is called the *six-foot way*. It is that portion which separates the two trains going in opposite directions. As a general rule trains all travel on the *left-hand* pair of rails when more than one pair exist, and the case of a single line of rails is very rare here, because the traffic is so large. In America it is very common, and in such cases trains passing in opposite directions have to wait until one has passed into a station where two pairs are laid. If this be neglected, an accident must surely happen, for two trains would then be travelling in opposite directions on the same line, and a *collision* would result. Near large stations many pairs of rails are laid, and the Camden Station of the London and North-Western line affords an excellent example of this.

To enable a train to *shunt*—that is, to shift from one line to the other—*switches* and *points* are used. A curved line extends between each pair, but does not join them. By means of a lever, however, the edges of this curved line can be forced against the sides of the main line, and the train will then pass on or off it as desired. This operation is called "working the switches;" and a man is generally kept constantly at the place where this arrangement is worked. Sometimes, when the *pointsman*, as he is called, neglects his duty, or improperly moves the switches, he causes the train to run off the line, and thus many serious accidents have happened.

There are many *signals* used on a railway, which we must here explain. A white flag denotes that the line is clear and may be safely run over; a green one shows that the train must proceed cautiously; whilst a red flag, on being shown, is intended to instruct the driver at once to stop, for it is dangerous to proceed. Of course these flags could not be seen at night, hence a lamp is used, which can be covered with green or red glass as required. At stations, hand-lamps are adopted; but at some distance on each side, and also near the station, similar lamps, fixed on the top of high poles, are placed, so as to indicate to the engine-driver, long before he reaches the station, whether or no he may proceed.

Nothing is more important than the *signalling*, as on it depends much of the safety we now experience in travelling at great speed. Sometimes the train leaves the "metals," or rails, despite every care. This may arise from something on the line, as a cow or other animal strayed thereon; obstructions wilfully placed on the line; and at times the wheels run off without any apparent reason; but this is of very rare occurrence, and almost always arises from the gauge having been accidentally altered. At the present day a railway "accident" rarely happens, or can happen, from any cause except that of carelessness.

We must now turn to the train, engine, &c. A *train* consists of any number of *carriages* connected together by chains and other contrivances. The carriages are divided into classes, according to the style in which they are finished internally; and the best, or first class, in that respect resembles an ordinary road carriage. Externally, however, such is not the case; the springs are much stronger, for the carriage is much heavier, the wheels are made of iron, and at each end is a *buffer*, which consists of a block of wood, fitted on to springs so arranged that when one carriage strikes another, the force of the blow is received by these springs, and so spent without shaking the passengers.

The train is made up of various kinds of carriages, sometimes including *trucks*, used to hold cattle, goods, &c., and made in a much rougher manner than those holding human beings. A *turn-table* is generally found at stations. It is a contrivance by means of which a carriage can be directly shifted from one pair of lines to another. It is in reality a table fixed on a pivot, and on the table are two pairs of rails across each other. To shift a carriage or engine the table is turned half round, so as to meet the cross rails of another table on the adjacent line. The carriage is then moved on to the second table, and this is then turned half round, when the carriage can then be moved on the second pair of rails, lying parallel to those it had previously been on. By such means a carriage may be easily moved right across the station, without the trouble of using switches and points, and running it up or down the line, which would be necessary without such a contrivance. The *breaks* are pieces of wood fitted over the wheels, and on to which they can be forced by means of a screw. Their object is to stop the movement of the wheel; and it is by a number of these spread throughout the train, either attached to the ordinary or a separate carriage, called a *break van*, that the *guard* or the engine driver can stop the train while in rapid motion. It is the business of the guard to look to the safety of the train generally, but especially to pay heed to the signals of the engine driver made by the whistle, and to use the breaks accordingly, whilst the train passes from station to station. In *mail trains* a special carriage is attached, in which the letters are sorted as the train proceeds; and thus the latter frequently becomes a travelling post-office. At small stations there is frequently an ingenious contrivance by which the mail bag can be safely delivered although the train may be travelling at full speed.

The *locomotive,* or engine, which draws the train next demands our attention. It is attached in front of the train, and in most cases is accompanied by a *tender,* which carries the coke, coals, and water necessary "to feed" the engine, or, in other words, to provide it with fuel and steam. The plate illustrates the chief parts of a locomotive engine; and we must refer our young readers, for a full description of steam engines generally, to the end of our next subject—that of sailing and steam-ship building, where, under the head of the "Engineer," they will find all particulars. In the annexed plate A is the fender receiving cinders from the bars, B, of the fire-box, C; here the coke is burnt, which is supplied to the furnace by a door, D. The tubes, E, in the boiler convey the smoke to the chimney-box, F, and thence it passes, with the waste steam from the engine, through the funnel, G. The boiler, E, is supplied with water from the tender by the pipe H, connected with the pumps I and K and L. The steam from M, N, O finds its way through a dome, P, surmounted by the safety-valve, Q, through the pipe R, and stopcock S, to the cylinder T, at the other end of the engine; and by pressing above and below the piston in that cylinder it gives

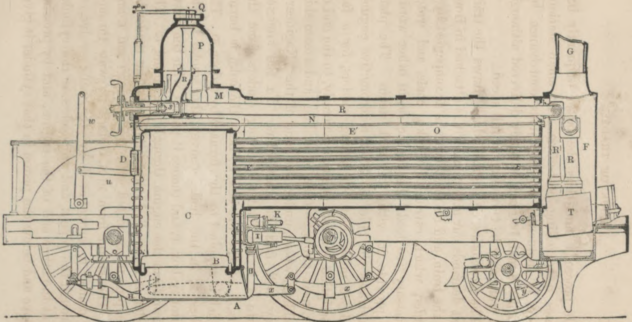


PLATE 20.—SECTION OF A GOODS LOCOMOTIVE ENGINE, p. 342.

motion to the crank of the driving wheel, g, of the engine. x, x, and y are springs supporting the engine on its framework. The eccentrics l, m are put in and out of gear by the lever and rod w and u; and thus the engine can be made to move backward or forward, as required.

Such is a description of a locomotive as used at the present day. It materially differs from the "Rocket," which was the first successful locomotive built by Stephenson, and which got the prize of £500 offered by the Directors of the Liverpool and Manchester Railway in 1829-30. Locomotives are used which exert a force of 1,000 horses, and are capable of drawing hundreds of tons on a railway.

The steam whistle, with which all our readers are familiar, is placed on the top of the boiler, in front of the engine driver. Two are often provided—one used on ordinary occasions, and giving a very shrill sound; and the other, much larger, which gives a deep sound, is employed as an extraordinary and urgent mode of signalling. The guard, if he hear one sharp whistle, puts on the break gently, or else looks out, ready for that purpose; if he hear two sharp sounds of the whistle, he puts the break on with full force. Thus the engine driver can hold a kind of conversation with the guard on his train, or persons at or near the station, with great ease and certainty, according to a code or plan agreed and understood by all.

A *parliamentary* train—so called because the Company is compelled to carry passengers by it at the rate of one penny per mile—generally travels at a speed of from fifteen to twenty miles per hour. An *ordinary* train goes at from twenty to thirty miles; and the *mail* or *express* frequently attains a speed of from forty to sixty miles in the same time; but when a train runs for an hour or two without stopping, a speed of upwards of seventy miles an hour is attained for short distances.

It is of great importance that the axles of the wheels should be kept cool; and this is done by *grease-boxes*, which are kept full of tallow or some kind of grease. This is a point looked to at each chief station as a train travels. A man is employed especially for that object. He also strikes the tyre of the wheels, one by one, with a hammer. If they give a ringing sound they are all right, but if not, the carriage is removed from the train, because when that sound is not given by a tyre it may be cracked, in which case it sounds like a cracked shilling or bell, because its rim must be somewhere divided. Many accidents have arisen from this cause; and when a tyre breaks off as the train is travelling, the carriages are generally thrown off the line, and fearful loss of life may happen.

Before we conclude our remarks about railways, we must say a few words about the *Electric Telegraph*, although we cannot spare space to describe it fully.* Nor can we enter into a description of the various substitutes which have been employed previously to its invention.

Referring to a description of a voltaic battery, given under the head of "Electro-plating" in the chapter on metals, at page 171, we may state that the electricity passes from the zinc plate, through the liquid of the battery, to the copper or silver plate, and back to the zinc plate, by the wire attached to both. Now, if the wire between the copper and zinc plate be made perfectly straight, and placed over, but not *touching* the needle of a mariner's or common compass, the needle will be turned either to the right or left from the wire, because the electricity in the wire acts so on the magnetism in the needle as to lay them *across* each other. If the electricity pass from the north to the south, the needle will turn to the right hand; but if from the south to the north, then the needle will turn to the left. And thus, by changing the direction of the current, which is easily and quickly done, the needle may be turned right and left many times in a minute.

But still our young readers will not understand how this can be made into a telegraph, or message-carrier; but we will easily explain it. We must first, however, remark that, no matter how long the

* For a full description of the Electric Telegraph, and methods of making simple instruments for the use of young people, see the article on that subject in the *Magic of Science* (GRIFFIN & Co.), by the author of this work.

wire—whether it be an inch or 500 miles—the same effect can be produced *at each end at the same moment;* so that if a person had a magnetized needle so arranged in London, and another person had one similarly in Glasgow, the moment the electricity sent by the London battery reaches the wire, both needles would be turned right or left at the same instant of time, for electricity travels at the rate of many thousand miles per second.

Supposing now that two currents were sent rapidly after each other by the wire to Glasgow, the needle would thus be turned twice right or left—say twice to the left. This signal signifies the letter A. We will now suppose that, by the same means, the needle is turned twice to the right. This indicates N. Next, the telegrapher causes the needle to turn once to the left and once to the right. This indicates D. Thus the word AND has been spelt at the same moment both in London and Glasgow; and in the same way any number of words, at the rate of twenty or thirty a minute, may be telegraphed with perfect ease; and persons may so talk by electricity as easily and certainly as they can do with their tongues.

We have only explained what is called the "Needle Telegraph," but there are many others used. By any one messages can be sent instantly from station to station; and thus each *station-master* can inquire of another station when a train has started or arrived, and ascertain anything he may desire at any moment, although he may be miles away. It is by such means alone that railways can now be safely managed; and on many lines no train is allowed to pass one station or tunnel until the train preceding it has been telegraphed to be at a safe distance from it.

THE SHIP AND BOAT BUILDER.

Perhaps one of the most interesting matters with which we could entertain our young readers would be that of tracing the history of boat and ship building. But to do this would require much more space than we can spare, and we must therefore only say a few words on the subject, and then pass on to a description of the trade.

In early times we read that wood was the chief material of which boats and ships were built; and it is astonishing that until long within this century, iron, now so universally adopted, was not thought of as a material. It is most probable that logs of wood, attached together so as to form a raft, was the first kind of "ship" adopted; and as it was difficult, and sometimes impossible, to steer such a rude contrivance, the proper shape of a boat was gradually arrived at, until at last a vessel was built which so far exceeded all previous to it as to become the model on which subsequent builders have improved up to the present time.

Wicker-work, covered with hides to keep it water-tight, the bark of trees, a log of wood hollowed out by fire, and many curious contrivances, have been, and are even still employed by savage tribes to form boats or canoes—the latter term being applied to the "boats" of savage tribes at the present day. In the northern parts of America the Esquimaux make their boats of hides stretched over a kind of wooden framework, and they are so light that they can easily be carried about until required on the water as a means of passage or for fishing.

At the present day the Chinese junk is perhaps the most curious specimen of shipbuilding; but this need not surprise us, for, as a rule, the Chinese do everything in a manner different to the rest of the world. In many other parts of the world however, we may find the style of shipbuilding very different to our own, which doubtless appears as strange to the people we speak of as their method does to us.

In our own country the earliest kind of boat used, of which we have any account, was the "coracle," which was made of wicker-work covered with hides, and therefore to some extent resembling the boat of the Esquimaux, to which we have just alluded. Canoes, however, of a kind resembling those still used in the South Seas have been found buried in the sand of some of our rivers, and such vessels were made out of the trunk of a tree hollowed out by fire.

We are indebted to King Alfred for the first fleet of war vessels, although a rude kind was employed

PLATE 23.—CHINESE FLOWER BOAT, p. 348.

PLATE 24.—SOUTH SEA CANOE, p. 348.

against the Romans when they first invaded Britain. Gradually the wretched style of ships were improved, as the knowledge of shipbuilding was acquired, and in the time of Henry VIII. a vessel of immense size, at least for those times, was built. It was called the "Great Harry," or "Henry Grace à Dieu," and there is a picture of it still to be seen at Windsor Castle and at Greenwich Hospital. In the time of Queen Elizabeth shipbuilding had made great progress, and all our young readers will have read an account of the Spanish Armada, so valiantly defeated by the celebrated Drake, in 1588. We must not pursue this history any further, but refer to another subject connected with it—namely, the method adopted for propelling or moving vessels of all kinds and sizes.

The use of oars or paddles is very ancient, the Grecian and Roman galleys having been thus propelled at least 2,000 years ago, and illustrations of which are frequently found on ancient sculptures. But those nations, as well as the Phœnicians, also employed sails, of which mention is frequently made in Hebrew, Greek, and other ancient writings. The methods of steering by means of [illegible]; and we read [illegible] ago. But it is barely half a century ago since the steam engine was first employed to drive vessels, and from that day that shipbuilding has made [illegible] progress and done more for mankind. We can well remember—and that not many years ago—that a celebrated philosopher proved against the Romans when they first invaded Britain. Gradually the size and style of ships were improved, as the knowledge of shipbuilding was acquired, and in the time of Henry VIII. a vessel of immense size, at least for those times, was built. It was called the "Great Harry," or "Henry Grace á Dieu," and there is a picture of it still to be seen at Windsor Castle and at Greenwich Hospital. In the time of Queen Elizabeth shipbuilding had made great progress; and all our young readers will have read an account of the Spanish Armada, so valiantly defeated by the celebrated Drake, in 1588. We must not pursue this history farther, but refer to another subject connected with it—namely, the method adopted for propelling or moving vessels of all kinds and sizes.

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It will thus be seen that there are chiefly three modes of propelling vessels—namely, by oars, sails, and the mechanical power of steam. We shall first speak of the mode of constructing wood and iron vessels, and then deal with the power which drives them through the water, explaining the trades on which depends the fitting and furnishing all kinds of vessels.

The first step is to draw a plan of the vessel which is to be constructed; and this is done on paper, all the lines being drawn to scale—that is, they represent the actual size of each part, but by a reduced size or scale. In other words, if a plank be six feet long, it would be drawn on the paper-plan an inch and a half long, or at the rate of a quarter of an inch to each foot of actual length. Each ship must of course have a separate plan of its own, corresponding to its size or tonnage. By this last term we mean the number of tons, *by measurement*, which the ship is to carry—a *ton* consisting of a bulk measuring 40 cubic feet. A bale or box measuring five feet long, four feet broad, and two feet deep would measure a ton; for as cubic measure is that in which length, breadth, and depth are multiplied together, $5 \times 4 \times 2$ just gives 40, the number of feet in the ship's ton. This "ton" weighs a little more than the ton avoirdupois, that being 2,240 lbs., whilst the former weighs—of water—about 2,400 lbs.

The next step is to set out the plan on the floor of the mould-shop, which is a room large enough to permit of the entire and actual size of every plank, &c., being marked down. From the lines thus made, a kind of model is formed out of thin planks, and these guide the shipwright in the construction of every timber in the vessel, whether thick or thin, straight, curved, &c.

The next step is to prepare each timber, and for this purpose the wood is cut out of the log, by adzes and other tools, to correspond with the pattern just described. The ribs and other large pieces are first sawn in the manner described already, under the head of the "Sawyer," at page 284; and great care is taken to choose the strongest and most suitable woods. Oak, and teak which is an Indian kind of oak, and a very hard wood, are chiefly used. The best oak is that grown in England, especially that obtained from the New Forest, in Hampshire; but teak being cheaper, and obtainable in larger logs, has been much used of late years. The shaping, &c., of the timber or logs is technically called "converting."

And now for a description of each part of the ship. The *keel* is that long part of the vessel which forms its lowest part, to which the ribs are attached, and from which they rise upwards to form the body and sides of the vessel. To illustrate these we may compare the keel to our backbone or spine, whilst the ribs of the ship correspond to those of our body. At the fore-part of the keel the *stem* is fixed, and it rises thence to form the *bows* or front of the vessel. At the hind-part is the *stern-post*, on which the *rudder*, which steers the vessel, is afterwards attached. Across the keel the *floor-timbers* are then laid, and these form the bottom or flat portion seen when we look from the deck of a vessel into its *hold*, as the inside of a vessel is called. Between the floor-timbers and the keel, wood, called *dead wood*, is placed, the object of which is to raise the floor at each end of the vessel. The entire ship is called a *hull*—that is, all that extends from the keel as far as the top of the highest *deck*—a term applied to each floor in a ship, and corresponding to that of "storey" as used in respect to our houses. The ribs being too long to be composed of one piece, they are made up of "futtocks," or foot-hooks—that is, separate pieces carefully and strongly united together. These ribs are kept together by planks, called ribands, outside; but inside are beams stretching across the vessel, and in some respects corresponding to the "joists" of our houses. On these beams the flooring of each deck is afterwards fixed in a manner similar to that adopted in "flooring" our houses. There are many contriv-

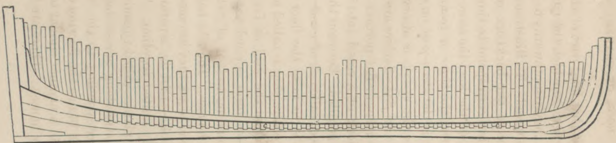

PLATE 25.—SECTION OF A SHIP'S TIMBERS FROM STEM TO STERN, p. 352.

ances for securing all these parts together, and making them strong, which we have not space to describe.

We must now speak of the "skin" of the ship, as we have thus described its skeleton. The outside of the vessel is formed by fastening on to the ribs thick planks, as close as possible to each other. In some parts this planking must be curved; and this is done by heating the wood by steam, which renders it pliable, as we have already described at page 328. The planks are fastened to the ribs, &c., by "trenails"—that is, long "nails" made of oak; and the shipwright makes holes in the timbers by means of an "auger" (a kind of large gimblet), and then drives the trenails in with great force by a heavy hammer. Iron and copper bolts, or large nails, are also used.

But however strongly and closely the planks may be thus fitted, they would leak—that is, let water into the ship when she is launched—and hence the business of the "caulker." He drives between every seam or opening some oakum, formed by untwisting old rope. The threads are placed lengthways with the seams, and the "caulking-iron" forces them in. The outside of the vessel is then covered with melted pitch; and thus she is rendered nearly water-tight. If not, the wood generally swells so much, soon after the ship is launched, that the few holes or seams quickly fill up.

Large wooden vessels are frequently "copperbottomed"—that is, the lower part of the hull, which is constantly exposed to the action of the water, is coated with copper sheeting, or some alloy of that metal. The sheets are securely and closely fixed on by means of copper nails; and a vessel so protected lasts much longer, and is not liable to be coated with shell-fish, barnacles, weeds, &c., which would greatly diminish its speed in the water if allowed to accumulate. This often happens to vessels which go long voyages, and hence they require to be taken into dock to have the bottom cleaned.

And here we must say something about docks, shipbuilding yards, &c. Docks are of two kinds—*wet* and *dry*. In the former the vessel only swims in the water to take or unship her cargo, or to receive such repairs as can be made above water. But in the dry dock she may be literally dry—that is, she is first allowed to float into the dock, which is provided with flood-gates, by means of which the water in this and the wet dock can be completely separated. The water in the dry dock is then completely pumped out, and so the shipwright or other workman can do work just as well as if the ship had not been launched. When the repairs are completed, the water is again admitted into the dock, and the vessel is then floated out. Docks are generally large spaces formed by digging out the ground to a depth of about twenty feet, and sometimes covering a surface of several acres. Between them and the river or sea is a *canal* or strip of water, separated from the dock by gates, so that the water can be kept, let in or out, as required. Of this kind are the docks at London, Liverpool, Hull, &c. But in many cases the river is made to serve as a "dock;" and thus the Clyde serves as a "dock" for the merchants and others at Glasgow. *Graving docks* are in most respects similar to dry docks.

We may mention that of late years an ingenious plan has been devised for raising vessels on a kind of platform out of the water, so as to prevent the necessity of dry docks; but we cannot stop to describe the method thus employed.

Shipbuilding yards contain every requisite for their object. There is the timber store, the forge, smithy, carpenter's shop, and numerous other conveniences involved in the work of shipbuilding. Sometimes the vessels are built under cover, in a place called a "shed,"—a plan most generally adopted in the dockyards of Woolwich, Sheerness, Portsmouth, and Plymouth, where war vessels are built.

The launching of a vessel is a matter of great interest. Before that event in a ship's life, she is said to be on the "stocks"—a term applied to the framework of wood on which she is built, and which rests on the ground, inclined towards the stream or river. The vessel is always built with its stern, or that part where the rudder is fixed, towards the water; and on launching, the stocks are knocked away by the workmen, the vessel gently moves, and acquiring impetus, rushes into the water, her further progress being restrained by ropes attached to places on shore. The "christening" or naming of the vessel is done at the same time, a bottle of wine being broken on her "bows," and her name being pronounced. She is then "towed" or led away to a convenient place; and the next step is that of "rigging" her.

By "rigging" we mean the fitting up of her masts, spars, blocks, ropes, &c.; and to this important part of the ship we must devote some little space, but must state that the term rigging is only employed, in a sea-faring or nautical sense, to the ropes. The masts are a most important part of the vessel, because on them are fitted the "yards," to which the sails are attached that give motion to the vessel. In small vessels, as the cutter, yacht, &c., only one mast is used; in brigs and schooners there are always two; in the "ship" proper three; and of late years even as many as five masts have been employed.

The mast in large ships is formed of several pieces strongly fitted together, and the lower part is firmly fixed in the "hold" to the keel of the vessel. The *yards* resemble masts, but taper towards each end, and are fitted on and across the masts: to them the sails are attached. The *bowsprit* is that "spar" which stretches from the fore-part of the deck of a vessel far beyond its bows, or front part, and to which certain small sails are attached. It is placed before the "fore" or front mast of a ship.

The "rigging" consists of those ropes which are essential to the support of the masts in their places, those employed in shifting the sails, and the cable or thick ropes used for holding the ship at anchor or against the side of a dock or harbour, or the *quay*, as that place is called. The *standing rigging* is that portion which supports the masts and yards, and is composed of "shrouds," &c.; whilst the *running rigging* is that which is continually moved when the sails or yards are shifted, and to facilitate which *blocks* or *pulleys* are used; and this introduces us to the trade of

THE ROPEMAKER.

The material employed by the ropemaker is chiefly hemp, of which we have already spoken fully in the first chapter, when describing the various raw materials employed in the linen manufacture. Jute and many of the vegetable products named at page 18 are also used at the present day in rope and twine making.

The "rope-walk" is a long shed several hundred feet in length; and one of the largest is that in Devonport dockyard, where cables, &c., used for the Royal Navy are largely manufactured; and there steam machinery of a most ingenious kind is employed in place of the hand method adopted in many private establishments. The hemp is prepared as if for spinning (see page 20), and a man ties a portion round his body, as a supply during the spinning of each thread required in a rope. A wheel, turned rapidly either by hand or steam, is placed at one end of the rope-walk, and the workman attaches some fibres to a hook on the wheel, which is then set in motion. As it turns round it twists the fibres, and more of them are continually added from the hemp which the man holds, he moving slowly away from the wheel, and thus gradually forming a single thread. It is of such threads, twisted together in various numbers, that the rope or cable is afterwards made.

If the rope is to be a tarred one, then the thread just described is passed through melted tar, and wound on to bobbins. It is then ready for twisting, and this is done on a most ingenious machine. A kind of carriage running on a railway, and possessing hooks to which the yarn is attached, is employed, the hooks being caused to revolve, and so to twist each thread together into a round strand. In making heavy cables, however, the process is modified by employing a machine which twists the yarns as they are drawn from bobbins on which they are wound, somewhat after the fashion we described as followed in making sewing cottons. We have seen such a machine at Devonport, twisting yarns and making a cable which was several inches in diameter, and intended to hold a large line-of-battle ship.

In making these large cables the processes are, successively, that of spinning the single yarn, that of twisting the yarn into a strand, then of combining a number of these strands together to form a rope, and lastly, of twisting a number of these ropes together to complete the cable. If our young readers can visit an ordinary rope-walk, they may see all these processes in operation, excepting the last, which, to be observed to advantage, is best done in a large shipbuilding establishment, or one of the public dockyards.

By such means as we have briefly described every variety of common twine, string, rope, and cable are made; and, so far as the ship is concerned, it is the business of the *Rigger* to fit them to their proper use in the ship; and this he does by aid of blocks or pulleys, when running rigging is employed. These blocks, which are made out of hard wood, were formerly manufactured by hand, but now steam machinery of a most ingenious kind is employed. Rings, dead eyes, bolts, &c., are used, through which the ropes run, or by which they are fastened. The large ropes are "bent" before use—that is, being very stiff, from their great weight and size, they are stretched and made supple, or soft, before being fitted in their places.

THE SAILMAKER.

We have already described the construction of the hull of a vessel, and the manufacture of ropes,

&c., for its rigging. We must now speak of another important trade, by which the sails of the vessel are made; for on the sails depend not only the ordinary motion of the vessel through the water, but in many circumstances, as tempests, hurricanes, &c., the lives and property on board depend frequently on the quality of the work and material which the sail-maker has supplied.

A sail is really a very large sheet of coarse cloth properly sewn together. The cloth or canvas of which it is composed is made from a coarse flaxen yarn, bleached by washing and exposure to the air, and woven on a large loom similar to that we have described as employed in making calico, at page 12. In fact, cotton sails are now largely used, and these may be truly described as calico of a very coarse quality. The canvas when thus woven is made up into bundles called bolts, and its strength is generally estimated by the weight of a bolt, which, whilst it measures forty yards in length, may vary from 20 to 50 pounds in weight, according to the quantity and quality of material used in its manufacture.

Sailmaking consists in sewing together the canvas so as to form the various shaped sails employed on board ship. The square sail, jib, &c., have each different shapes; and the canvas is cut out from the bolt accordingly by a knife. Strong twine, which has been previously soaked in tar and tallow, is used as the "sewing thread;" and large three-cornered needles, an iron shield for the inside of the hand, and a coarse thimble, are the tools. The canvas edges are lapped over each other, and the stitching is then effected in double rows, so as to unite the parts as strongly as possible. Round the edge of the sail a rope is sewn on to protect it from tearing, and to receive "eyes" and other ropes, by which it can be raised or lowered when in use; and by these it is attached to the yards on the masts. Small lines sewn on the canvas are employed to fasten up or furl the sail when not required or used, and to prevent its being blown about by the wind when furled.

THE ANCHOR AND CHAIN MAKER.

We have chiefly spoken of ropes or cables as being used to secure ships, but of late years iron chains have been much used. These have the great advantage of being durable, and are not liable to injury from moisture, insects, &c., and, what is of still greater importance, they can be so made that each part shall have an equal strength with the rest—a quality which the best hempen rope is never certain to possess. Chains are made of iron rods of various thicknesses, according to the strength required. A length of iron rod is cut off by a chisel, and then bent round into the form of an oval loop; another rod is inserted into this loop and similarly bent, and, to prevent the loops bursting asunder, these ends are welded together (see page 139); and to these centre rods of iron are inserted, which bind the sides together.

Anchors are forged out of solid bars of wrought iron by means of heavy hammers driven by steam. They are used to "hold" a ship when at rest in a stream, or at sea, if the ground is not too far off to permit of an ordinary cable extending from the anchor to the ship. They are made of various sizes and weight: the larger the ship the heavier must be the anchor to hold it. There are many kinds and shapes, but these we cannot stop to describe. At the present day chains are almost universally used instead of hemp cables to hold the anchor. Whilst the vessel is sailing, the anchor is generally suspended at the bows, or laid securely on deck. On its being wanted, it is technically said to be "let go"—that is, the chain and anchor are cast overboard, and allowed to run out until the anchor reaches the bottom of the water. The other end of the chain is secured to some part of the vessel, and the loose chain is "hauled" or pulled in, and affixed to the *capstan*—a circular piece of wood or metal which turns on an axis, and is moved round by rods or spars of wood by men, when either the anchor has to be "weighed" or raised.

We must now speak of the general fittings of a ship, and describe some of the names applied to its different parts. The hull, masts, yards, bowsprit, sails, rigging or ropes, anchor and chains, we have already mentioned; and the following is a list of the countries where they are invited, which kind the wider lodgment.

Amongst the ingredients of what bees appropriate [illegible] by means of heavy holdfasts [illegible]. They are used in [illegible] a [illegible] for the [illegible] [illegible]. There are many knots and shapes, for they vary without stop or reaching. In the [illegible] [illegible] [illegible] [illegible] universally used [illegible] the bottom of the [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to some [illegible].

We must now speak of the [illegible] of the

PLATE 26.—FRIGATE, FULL RIGGED, p. 363.

various parts of each, with the names applied to them by sailors. They are illustrated in the plate, which represents a frigate, and at the same time shows all the different parts of an ordinary three-masted ship used for conveying passengers and merchandise :—

NAMES OF THE PARTS OF A SHIP.

A THE HULL.

INCLUDES the whole of the body of the vessel.

1. Stem, or cut-water.
3. Quarter gallery.
M. Gangway.
N. Launch.
O. Jolly boat.
P. Cable.
R. Buoy.
4. Rudder.
5. Counter.
6. The bows.
7. The head and head rails.
8. The channels or chains.
9. The quarter.
10. Stern.
11. Figurehead.
12. Cathead.
H. The bends.
K. The quarter-deck.
L. Forecastle.

B THE BOWSPRIT.

1. The spritsail yard.
2. The jib-boom.
3. The dolphin striker.
4. The bobstay.
5. The guys.
6. The cup.
7. Martingales.
8. Flying jib-boom.

IV. Foresail.
V. Foretop-sail.

C THE FORE-MAST.

1. The foretop-mast.
2. The foretop-gallant-mast.
3. The fore royal mast.
4. The foretop.
5. The foretop-mast cross-trees.
6. The fore-yard.
7. The foretop-sail-yard.
8. The foretop-gallant-yard.
8. The fore royal yard.
10. The forestays.
11. The foretop-mast-stays.
12. The foretop-gallant-stay.
13. The fore royal stay.
14. The fore rigging.
15. The top-mast back-stays.
16. The top-mast rigging.
17. The cap.
18. Lower lifts.
19. Top-sail lifts.
20. Top-gallant lifts.
21. Fore-tack.
22. Fore bowline.
24. Reef points.

D THE MAIN-MAST.

1. The main-top-mast.
2. The main-top-gallant-mast.
3. The main royal mast.
4. The main-top.
5. The main-top-mast cross-trees.
6. The main-yard.
7. The main-top-sail-yard.
8. The main-top-gallant-yard.
9. The main royal yard.
10. The main-stays
11. The main-top-mast-stays.
12. The main-top-gallant-stay.
13. The main royal stay.
14. The main rigging.
15. The main-top-mast backstays.
16. The top-mast rigging.
17. The cap.
18. The lower lifts.
19. Main-top-sail lifts.
20. Main-top-gallant lift.
21. Main-top-sail braces.
22. Main braces.
23. Main-top-gallant braces.
24. Pennant.
+ Truck.

E THE MIZZEN-MAST.

1. The mizzen-top-mast.
2. The mizzen-top-gallant-mast.
3. The mizzen royal mast.
4. The mizzen-top.
5. The mizzen-top-mast cross-trees.
6. The cross jack-yard.
7. The mizzen-top-sail-yard.
8. The mizzen-top-gallant-yard.
9. The mizzen royal yard.
10. The mizzen-stay.
11. The mizzen-top-mast-stay.
12. The mizzen-top-gallant-stay.
13. The mizzen royal stay.
14. The mizzen rigging.
15. The mizzen-top-mast backstays.
16. The gaff.
17. The spanker or driver boom.
18. The vangs.
19. The boom topping lifts.
20. The ensign staff.
21. The ensign.
22. The peak haulyards.
+ Truck.

If a vessel have more than one deck, that which is at the top is divided into the *quarter-deck*, nearest the stern; the *forecastle*, which is at the bows; and the *waist*, which is between the two former. The openings down into the lower deck or hold are called *hatchways*, and are used to load and unload the cargo, &c. They are closed except when thus required; but one or more are used to admit the sailors to their berths. The *companion* is a kind of staircase, by which the passengers and chief officers descend to their cabin or berths. The next deck below the quarter-deck is called the *main deck* in war vessels; that next lower is the *middle gun-deck*, and the one under this is the *lower deck*. The lowest deck of all is called the *orlop deck*. War vessels have their sides pierced with holes called *ports*, through which the guns project when they are about being fired off. In merchant vessels similar holes are made, with, however, the more peaceful object of allowing light and air to pass into the cabins.

The interior of a ship is divided into various-sized portions, in respect to that devoted to the use of passengers. The sleeping-places are called *berths*, whilst those corresponding to the sitting-rooms in our houses are called cabins. Some vessels are most handsomely fitted up, and, indeed, vie in that respect with the most stylish drawing-rooms in our houses. The tables have ledges and other contrivances for preventing glasses, plates, &c., from falling off when the sea runs high. We have often seen amusing accidents arise when vessels not thus fitted had gone out on a sea trip during rough weather. The landsman, in such cases, may expect the soup and other drinkables to be lodged in his lap whenever a lurch of the vessel suddenly takes place. The largest vessels are liable to pitch and roll, and even the "Great Eastern" forms no exception to this unpleasant rule.

In navigating a ship many instruments are needed, one of the most important of which is the *compass.* Our young readers will all know that this chiefly consists of a magnetized needle, which points at one end nearly northward. In ancient times, before the compass was discovered, the mariner had to depend on the stars to guide him at night; and in foul weather he was obliged to cast anchor, or take his chance, not knowing whither he was steering. In those days nearly all voyages were confined to the coasts; and hence the length of time which elapsed before the discovery of America, the sailors not daring to trust themselves out at sea, and possessing nothing to guide them.

We have not mentioned the different names applied to vessels. A boat is the smallest, and is generally moved by *oars;* barges, lighters, &c., are similarly moved, although on canals horses are employed for drawing barges; brigs and schooners have each two masts, the former having both, but the latter only one mast fitted with square sails;

ships or barques have three masts, two of which, the fore and main, are usually square-rigged.

IRON AND STEAM VESSELS—THE ENGINEER.

The building of iron vessels is a great novelty in shipbuilding, scarcely more than thirty years having elapsed since that material has been employed. Our young friends may be surprised that iron should swim in water; but it must be remembered that any object will thus float, provided its bulk weighs less than the same bulk of water. Now, it is only the case of the vessel that is made of iron, and the entire bulk of a vessel thus made weighs very much less than the same bulk of water, and the difference of these two weights is the *tonnage*, or carrying capacity of the ship.

Iron shipbuilding is a much more simple affair than that we have described in respect to wood shipbuilding. The keel is made of iron plates rivetted together; and ribs, also of iron, extend upwards, just alike in shape to those of wood vessels, but of much smaller size, because the same weight of iron is very much stronger than wood. The planking is also of iron, rivetted together in such a manner as that every part is water-tight, the heads of the rivets being cut off on the outside of the vessel, so that they may not impede its motion. The method of rivetting is explained at page 145, in connection with the trade of the boiler-maker.

The masts of these vessels, and even the yards, are often made of iron, and they are much stronger and lighter than those made of wood. Of late years steel plates have been used both for vessels and masts; and it is likely that, before long, this material may be universally employed, for it is lighter and stronger than even wrought-iron.

Glasgow is the chief place for iron shipbuilding; and each bank of the Clyde is covered with iron shipbuilding yards, the noise from which is truly deafening to those unused to it. Many such yards are also found on the banks of the Thames; and, in fact, wood shipbuilding is almost going out of practice. War vessels of the largest class are now built of iron, and the *iron-clads* are coated with plates of that metal from four to six inches thick, to protect them from the shot of the enemy when in action. Another recent addition is a *ram*, which is a projecting mass of iron at the bows, and beneath the water. It is intended to act on an enemy's ship, by being driven with great force broadside on to it; and by such means it is considered that the largest and strongest vessel may be quickly destroyed.

We must now enter into a detailed description of the means by which these vessels are propelled; and we need scarcely tell our young readers that we are indebted to steam for the power thus exercised. When heat is applied to water, and it is made to boil, the liquid becomes converted into vapour or steam, which occupies 1,600 or 1,800 times as much space—that is, one pint of water would make 1,600 or 1,800 pints of steam. Now, so long as the steam is produced in an open vessel, it has no pressure beyond that of the air which surrounds it; but if it be produced in a close vessel, like a steam boiler, it can be made to press with any amount of force. Thus an ordinary steam boiler often sustains a pressure of steam inside equal to that of a weight of 20, 30, 40, 50, and even 150 pounds on every inch square of its surface; or, in other words, if the steam pressed against a piece of metal, say exactly an inch square, and which could rise in a tube, it would require as many pounds on the other side to keep that piece in its place as the pressure of steam. In the steam engine a *cylinder* is employed, in which a round piece of metal is so fitted as to be completely airtight; and steam being allowed to press above and below this *piston*, as it is called, causes it to rise and fall in the cylinder. From this piston proceeds a rod called the *piston-rod*, and this communicates with a *crank*, which is turned round once for each time that the piston makes a complete rise and fall inside the cylinder—a distance called the *stroke*. The steam is admitted above and below the piston by means of what is called a *slide-valve*, which works in a box attached to the cylinder, at the top and bottom of which are holes, or *ports*, by which the steam enters and leaves it. One side of the *slide-valve box* communicates with the *steam boiler*,

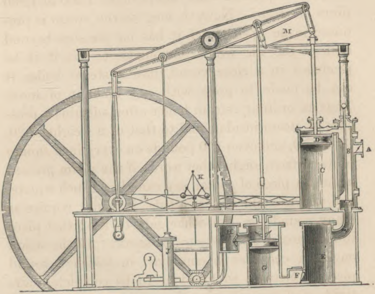

PLATE 27.—THE CONDENSING STEAM ENGINE, p. 368.

A Steam Passage.
B Slide Valve.
C Cylinder.
D Piston.
E Condenser.
F Valve to the,
G Air Pump.
H Escape for air and waste water.
J Pump for supplying water to boiler.
K Governor.
L Eccentric.
M Beam and parallel motion.

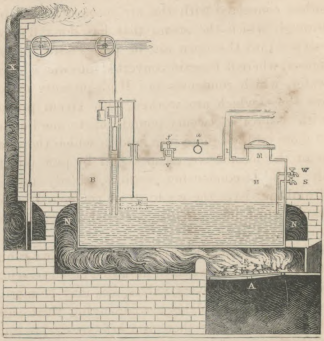

PLATE 28.—STEAM BOILER, p. 369.

A Ashpit.
B Steam.
E Furnace.
F Waterfloat, to show height of water.
I Steam pipe to engine.
M Manhole.
N Flues.
S Steam gauge cock.
V Safety-valve.
W Water gauge cock.
X Chimney.

by means of a *steam pipe*, whilst the other side is either connected with the air by means of a pipe through which the steam that has done its work escapes into the open air, or passes into the *condenser*, where it is again converted into water by cold water, which condenses it. High-pressure engines are those which are worked with steam pressing with a force of twenty pounds up to one hundred or more on the square inch, and in which the steam, as in the locomotive, escapes puff by puff into the air; whilst condensing engines, chiefly used in steamboats, have the waste steam condensed by cold water, which in their case is abundant, for they are surrounded by it.

The various details of the steam engine we cannot stop to explain, as we have indicated all the essential parts. The rods, levers, valves, &c., may be more or less traced in the plates accompanying these pages. On the steam boiler there is a *safety-valve*, to allow of the escape of steam when the pressure in the boiler becomes dangerous or excessive; the *water-gauge* shows the height of the water; and on these two connections of the boiler its safety chiefly depends: for the one allows of the escape of excess steam, whilst the other indicates the quantity of water, which, if deficient, would permit the sides of the boiler to get red-hot, and cause an explosion.

We have already explained the method of making boilers, under the head of the "Boiler-maker," in the chapter on "Metals." The material is, generally speaking, wrought iron, although steel has been used of late years. Formerly the inside in marine or steam-vessel boilers was fitted with flues or open spaces through which the hot air and flame from the furnace passed towards the chimney; and this plan is still adopted for boilers used in manufactories. But locomotive and steam-vessel boilers are now fitted with a large number of small but long tubes, which run from one end of a boiler to the other, and through which the hot air and flame pass, heating the water by which the tubes are surrounded. It is chiefly owing to this arrangement, which saves both room and weight, that our railway trains and steamboats travel so fast as they do at the present day; for the more steam that can be supplied to an engine in a given time the greater is the power, and therefore speed, which it will afford. In the locomotive the waste steam, as it puffs out of the chimney, draws with it an immense quantity of air through the furnace and fire-box, and so increases the draught and heating power. In steam vessels a small pipe from the boiler is fitted into the chimney, and the steam which is allowed to escape through it answers the same purpose.

The steam vessel, which has now become so universal both for general and warlike purposes, is but a recent invention. The earliest of the kind in our island was that of Henry Bell, who, in 1813, started on the river Clyde, near Glasgow, a small vessel, called the "Comet," propelled by an engine of three-

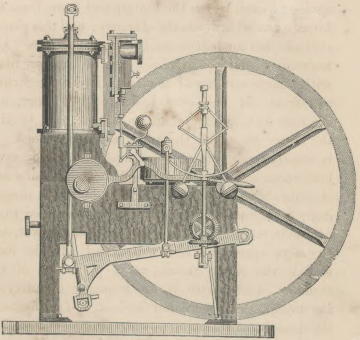

PLATE 29.—BELL'S STEAM ENGINE, p. 370.

horse power. This engine is still in existence, and was exhibited in 1857 at the Glasgow Polytechnic Institution, until the destruction of that place by fire, when it fortunately escaped injury, and was returned to its present owner, who resides near Glasgow. It is a most interesting object, as being the first machine used for propelling vessels by the agency of steam.

We must here explain what we mean by horse-power. It is a term applied to engines of all kinds, for the purpose of comparing their work with that of a horse in a given space of time. By many trials it has been found that a horse will lift at the rate of 33,000 pounds one foot high in a minute; and if a steam engine can do the same, it is reckoned as equal to "one horse power." If it can raise 66,000 pounds in the same time, it is called a two-horse engine; and so on. So that, if we want to know the horse-power of a steam engine, we have only to divide the number of pounds it can lift one foot high in a minute by 33,000, and we know its "horse-power." The "Great Eastern" has engines equal to several thousand horse-power; and she requires such, for she is the largest vessel yet made; and when loaded with the Atlantic Telegraph, in 1865, had nearly 20,000 tons on board, including engines, cable, &c. In fitting an engine to a vessel it is usual to allow one horse-power of the engine to every three tons of the vessel's measurement (see page 350); and hence a vessel of 3,000 tons should have engines equal to 1,000 horse-power; but this rule is not always kept to, for in river steamers, where speed is required, the power far exceeds this; whilst in vessels going very long voyages the engines are generally only used to assist in propelling the vessel when calms or adverse winds occur. At the present time two modes of propelling steam vessels are used —namely, by the *paddle* and by the *screw*. The *paddles* of a steamer consist of circular rims of metal fixed by rods, like the spokes of a wheel, on a shaft moved round by the crank of the steam engine. Boards, called *floats*, are fixed across from rim to rim, and these, as the paddle goes round, strike against the surface of the water, and drive the vessel in an opposite direction. Paddle-wheels are placed one on each side of the vessel, near its centre, and, of course, close to the engine by which they are driven. It is usual to have two engines in a steamer, which being fixed to the crank at different parts of the working of the piston, cause the paddles to rotate equally, and thus prevent an irregular motion of the vessel. "Feathering paddles" are those which, by an ingenious contrivance, are caused to enter and leave the water *perpendicularly*, and this prevents much of the "shaking" found when the common kind are used. The latter striking the water *obliquely*, cause the vessel to make little leaps, which produce the shaking we have just named, and also cause a loss of power.

The *screw* is a comparatively recent invention,

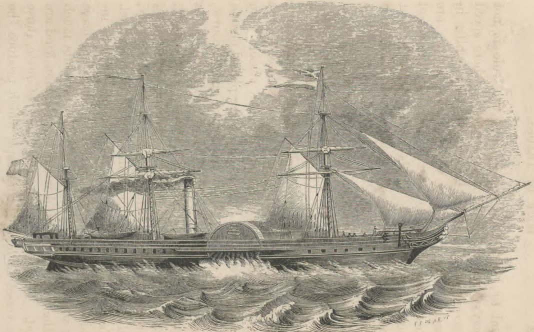

PLATE 80.—PADDLE STEAM VESSEL, p. 372.

and consists of a shaft or rod of metal, on which thinner sheet metal is fixed, in the form of the blade of a common screw, only one turn, however, being used, and often even less than that. The distance between the centre of each turn is called the *pitch* of the screw. It doubtless puzzles our young readers to tell how it is that a screw can thus propel a vessel; but they must remember that water is really a more solid or resisting substance than even iron itself. In fact, even a cannon ball is cast off the surface of water when it strikes it obliquely. Hence, when the blades of a *screw-propeller* strike the water, they force themselves against it, and as they are attached to the engine, and the engine is attached to the vessel, the latter leaves the water behind, or, in plain language, is forced from it, and goes on with force proportionate to that exercised by the engine. The steam engines employed to drive screw-propellers are so placed as to act on the shaft lengthways of the vessel, instead of breadthways, as in the case of paddles; for the screw is placed at the stern or back-end of the vessel, close to the rudder. The paddle-wheel propels a vessel, with the same power, faster than does the screw; but the latter has several advantages which makes it preferred for many purposes. The "Great Eastern" is fitted with both paddle-wheels and screw; but it has failed in this, as in every other respect, to answer the purposes for which it was built and engined.

One of the most interesting sights to a young person is that of a large steam vessel ready to proceed to sea; and those of our young readers who have not seen one has a treat in store. Everything is kept in neatness, order is everywhere prevalent, and, altogether, the size of the vessel, its fittings, furniture, cabin, engine, &c., make it a complete floating palace. The "Great Eastern" has carried some thousands in one voyage across the Atlantic to America; but smaller vessels, as the "Persia." and others employed in the carrying of passengers and goods, are only inferior to her in size, their other arrangements being quite, if not more perfect.

We cannot conclude these remarks without reminding our readers that to one person—James Watt—we are chiefly indebted for the steam engine as we now employ it. For a long time he worked in obscurity; but observing those two essential conditions, *perseverance* and *industry*, which alone lead to greatness, he at last invented an engine, on which, under Providence, the whole of the prosperity of our native country more or less depends in our day, and by the aid of which we are enabled to set at nought wind and water, and travel with a certainty and safety which are truly astonishing. Possibly some of our young friends may emulate such an example; and to encourage that feeling, we can only say that when the names of many of our greatest warriors and statesmen are forgotten, those of Watt, Stephenson, and the like, will survive; for those men taught us that peace has greater victories than war, and they have opened out to us sources of happiness and comfort which otherwise might have been for ever hidden from our view.

We cannot here enter into many other interesting matters connected with the means of travelling. Our small space has confined us to speak of the most important only; and we must leave our young friends to gather further information on the subject from works specially devoted to it.

THE CLOCK AND WATCH MAKER—MUSICAL INSTRUMENTS.

We must devote a small space to describe the most essential parts of that most invaluable of instruments, the clock, and of its younger brother, the watch. In our day, when travelling by rail and steamboat requires great punctuality, these two instruments are of the greatest importance. Formerly the sun-dial was trusted to, but this is rarely if ever correct; for, owing to the difference between the day, as shown by the sun, and that as indicated by the stars, there is sometimes a difference of at least a quarter of an hour from the true time. *Clepsydræ*, or water-clocks, were formerly used, especially amongst the Greeks and Romans. The hour or sand-glass, just like our egg-boiling glasses, was much employed, and amusing accounts have been related of mistakes arising from their being too soon turned or forgotten altogether. It is related of a whimsical divine that, when preaching to some young students addicted to the vice of drinking, he kept turning up the hour-glass in the pulpit several times, thus giving them a very long sermon. At each turn he hit their vices slyly by saying, "One more glass, gentlemen."

Now-a-days the clock and watch are the only means used for measuring time; and the principle on which they both work is the running down of a weight or spring, regulated either by the motion of a pendulum in clocks, or that of a balance-wheel in some clocks and all watches. The wheel-work of both is simply intended to convert a fast into a slow motion, and thus to keep the clock or watch "going" twenty-four hours, instead of as many or less minutes. We will now see how this is done.

On the barrel of a clock the cord passes, to the end of which a weight is attached, and it is this weight that gives the motive power of a clock; for when the weight has "run down," the clock stops. In a watch there is no weight, but inside of the barrel is a spring, and this acts on a chain attached to a conical barrel, called a fusee, which, on being turned round by the key, draws the chain from the barrel, stretches out the spring, and so "winds the watch up."

But if either clock or watch be wound up, and they are not provided with either pendulum or balance-wheel, they will run down in a few minutes,

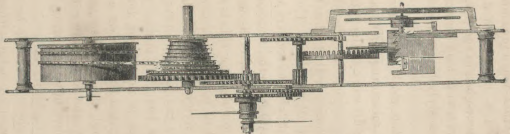

Plate 31.—Mechanism of a Watch, p. 376.

the heavy revolving rapidly on [illegible]. This seems [illegible] there have no power [illegible] to [illegible] leting that supplied by the [illegible]. In the common clock the pendulum is used for this purpose, and it depends for its action on the very same law which keeps the moon near the earth, and the earth and it near the sun. This power is called gravitation. Now, the pendulum, if a [illegible] more than 39 inches long, swings between one point and another in just a second, [illegible] part of a minute; and [illegible] this because the [illegible] the heavy part at the end of the rod tries to fall or [illegible] cannot do so [illegible] the rod? If, now, the pendulum be simply hung [illegible] to the clock-weight, [illegible] like all other moving bodies it cannot keep itself in motion. So then we perceive [illegible] the clock-weight gives the motion, the pendulum regulates it; and between these are numerous wheels and pinions with a different number of teeth, so arranged that the [illegible] shall pass [illegible] round the clock face once [illegible] while the hour-hand [illegible] twelve times that period [illegible] the same. It will be impossible for us to explain [illegible] all these wheels and their mutual action; but the plate gives a general view of the arrangement of the works of a watch, and if our young readers will open either a clock or watch they may [illegible] little patience master its details.

the hands travelling rapidly on the face. This occurs because they have no power controlling or regulating that supplied by the weight or spring. In the common clock the *pendulum* is used for this purpose, and it depends for its action on the very same law which keeps the moon near the earth, and the earth and it near the sun: this power is called *gravitation.* Now, the pendulum, if a little more than 39 inches long, oscillates between one point and another in just a second's time, or the sixtieth part of a minute, and it does this because its *bob*, or the heavy part at the end of the rod, tries to fall or gravitate towards the earth, but cannot do so because it is prevented by the rod. If, however, the pendulum be simply put in motion apart from the clock-weight, it will soon stop, because, like all other moving bodies, it cannot keep itself in motion. So then we perceive, whilst the clock-weight *gives* the motion, the pendulum *regulates* it; and between them are numerous wheels and pinions, with a different number of teeth, so arranged that the minute-hand shall pass once round the clock face each hour, whilst the hour-hand shall occupy twelve times that period in doing the same. It will be impossible for us to explain on paper all these wheels and their mutual action; but the plate gives a general view of the arrangement of the works in a watch: and if our young readers will open either a clock or watch, they may, by a little patience, master its details.

Of course, in a watch a pendulum cannot be used, but in place of it is a little wheel attached to a spring, and this spring, acting by its elasticity on the "balance-wheel," causes it to oscillate to and fro in a manner similar to, and as effective as, the pendulum of the clock. So that in a watch, or some clocks similarly moved, the elasticity of a piece of steel takes the place of the pendulum acting by gravitation.

The *striking* part of a clock is moved by a separate barrel and weight, and an ingenious arrangement of wheels, &c., regulates its motion in correspondence with that of the minute and hour-hand of the face of the dial or clock.

The manufacture of watches is carried on in our country chiefly at Clerkenwell, to the north-west of London, and at Coventry, in Warwickshire. Geneva, in Switzerland, is noted for its watches, as also is Paris, many towns in Germany, and in Europe generally. Some curious old clocks have been made, some of which not only point out the time of day, but also the day, month, year, &c. Attached to many are *automata*—that is, objects moved by other clock-work; and thus human, animal, and other motions are imitated. In fact, by such means some very curious machines have been made, as imitation men playing at chess, &c. Musical snuff-boxes and barrel-organs are moved by clock-work; and pins in a large barrel, by touching tongues of metal, produce the sound which they afford. The tune is regulated or produced by properly adjusting these pins on the barrel in a most ingenious manner.

Whilst speaking of musical instruments — to which we should have devoted a separate chapter had space permitted—we may make a few descriptive remarks. The piano, violin, and all instruments affording sound from strings, and therefore called stringed instruments, produce that sound by the vibration or shaking of the strings. The longer the strings the deeper or more *bass* the sound; and hence we find that the longest strings of the piano and harp are at the *bass* end, whilst as the sound gets shriller the wires producing them get shorter and shorter. In all such instruments a sounding board or its equivalent is produced, the object of which is to spread the sound. The body of the fiddle answers this purpose, as does that of the harp and piano. In these instruments the strings are caused to vibrate by touching them—in the harp with the fingers, and in the piano by means of keys, whilst in the fiddle the strings are caused to vibrate by the bow drawn over them. The length of the string in the violin, and consequently the depth or shrillness of the note, is regulated by the performer's fingers.

Wind instruments are those in which the air blown into them produces the sound; and in them the *length of the column of air*, instead of that of the wire in stringed instruments, varies the depth of the sound; hence the varying lengths of organ pipes. In the cornopean and other brass instruments this variation is accomplished by the performer, just as that is done on the violin, by the fingers, the instrument being stretched out or shortened according to the bass or treble notes required. The holes in the flute, fife, boy's whistle, &c., answer a similar purpose. The harmonium, accordion, and concertina depend on the vibration of thin metal tongues, which, as the air is forced past them, are put into motion, the keys supplying the air from bellows worked by the hand or foot of the performer. They are, comparatively speaking, a new invention, but are very much liked, and hence have come largely into use.

We see in all these instruments that the air is, after all, the chief cause of sound. When any object is struck, it is caused to vibrate, and these vibrations, spreading like waves in the water to our ear, affect its delicate organs, and make us hear the sound. If a musical snuff-box be placed in a glass vessel, and all the air be pumped out, no sound will reach the ear, because no air is present to carry the vibration. Hence we see that the air we breathe is not only essential to our lives, but to our pleasure and happiness; for without it our ears would be absolutely useless for want of a conductor of sound.

CHAPTER X.

TRADES CONNECTED WITH BOOKS.

MANY of our young readers would have suggested that we should have commenced our book with the present chapter on "Book-making;" but although this is a very interesting subject, we have thought it better that our book should be read before we describe how it has been prepared for sale.

In the first place we must describe the "raw material" of which books are made; and that consists chiefly of paper, type, and printing ink. The types are small pieces of metal composed of lead and antimony, cast in a mould which has inside of it a counterpart of the letter; that is, the raised portion of the letter is sunk or hollow in the mould; and into this the melted metal is poured. When cold, the type is taken out, and at its end the letter appears with a raised surface. There is a great variety of type, each of which has a different name. They are as follows, commencing with the largest and ending with the smallest in ordinary use,—viz., Great Primer, English, Pica, Small Pica, Long Primer, Bourgcois, Brevier, Minion, Nonpareil, Pearl, and Diamond. The types used less commonly, and often for fancy work, are,—Sanscrit, Egyptian, Black, Shaded, Script, Open Black, German Text, and

Condensed. The making of types for the Printer gives rise to the trade of the *Typefounder*. Of the history and uses of type we shall speak more fully when we describe the art of printing.

Printers' Ink is a kind of varnish, made of lamp-black, boiled oil, &c.; and the manufacture of it is carried on as a separate business. It is of the consistence or thickness of common treacle.

The remaining article constituting a printed book is the paper on which it is printed; and we must devote considerable space to the description of its manufacture, which becomes the business of

THE PAPER-MAKER.

The Paper-maker requires abundance of water for the purpose of his business, which is therefore always carried on near a river. In many cases the stream is employed to drive water-wheels, which afford the power required to move and work the paper-making machine.

The materials he uses are chiefly rags; but of late years, owing to the scarcity of that article, a vast variety of other substances have been used. Amongst these are straw; grass, especially Esparto grass obtained from Spain; fibres of the sugar-cane, agave, sun-flower, common grass, &c. We shall confine our description to that made of rags, after they are delivered at the paper factory.

The rags are first sorted by women, who also cut them to an even size, if such be required; and great care is taken that no woollen material enters amongst the rags intended for white paper, to which we shall confine our attention. The rags are then placed in a dusting-machine, in which the loose dust and dirt are removed. The next process is that of washing; and, at the same time, by iron bars fixed on a roller revolving rapidly in a trough of water, which is constantly being renewed, the rags are torn to pieces, and converted into a kind of coarse pulp. This pulp is afterwards removed and bleached in a chamber, by means of chlorine gas (see page 36), when the whole is converted into a perfectly white mass. This is then carefully washed; and in another vessel, by means of cylinders revolving very rapidly, and coated with knives, the pulp is still further acted on, becoming, with the water with which it is mixed, just like milk in appearance. At this stage the size is added, which afterwards prevents the absorption of writing-ink; for without this the pulp would simply produce an article exactly like, in fact constituting, ordinary blotting-paper. In some papers the colouring-matter is also added at this stage. The pulp is now introduced into a large vat, where it is kept in constant motion by means of a revolving roller and arms. From this vat the pulp passes into a square trough, which is always kept filled exactly to the same height; for on that being carefully attended to depends the evenness of the sheet of paper produced. Next, beyond the trough, is a wire frame, on to which the pulp flows and spreads in an even sheet. This frame is kept constantly in a jerking, horizontal motion, so as to spread evenly the fibre of the pulp on its surface, and to drain off through the wires a greater part of the water. The fibre gradually attains a consistency, which is increased by pressure of rollers covered with felt. These remove a still further portion of the water, and the paper, wet, then arrives at large cylinders, filled with steam, by which it is dried, and acquires a glossy surface. At last it reaches a roller, by which it is wound up in one continuing, increasing, and never-broken sheet.

This manufacture is one of the most interesting and beautiful of any carried on by man; and the spectator cannot help feeling the greatest astonishment at perceiving a thin fluid, apparently like milk when entering one end of the machine, converted, in the space of three minutes, into a beautifully even sheet of paper. During the manufacture, a curious phenomenon may sometimes be observed: it is that of the production of free electricity. We have frequently noticed sparks, of from two to six inches long, given off from the surface of the web; and this result is sometimes a source of much discomfort to the workman—raising the hair of his head, and occasionally giving him a shock.

In former times, paper was chiefly produced by hand, at the rate of a sheet at a time; the size, which was generally small, depending on that of the machine; and this plan is still adopted for many kinds of paper, but especially for Bank of England notes. These are made in a sheet, affording two only, so that each has but one cut edge. The principles of the hand-process are identical with those just described as adopted in the machine; and the great advantages of the latter consist in its speed, even quality, and the unlimited length, in one web, which it affords: in fact, if the machine be properly supplied with material, the process may be, and often is, carried on without a single stoppage, night and day, for a week together.

The coarser kinds of paper, as brown, packing, &c., are manufactured in a similar manner. For these, however, coarser materials are employed, such as old bags, ropes, and the like.

The paper is removed from the roller, and cut into sheets, and then packed up into parcels containing 516 sheets, and which form a printer's ream of paper; an ordinary ream of writing paper contains only 480 sheets, or 20 quires of 24 sheets each. The paper is now ready for the Printer, whose business we shall next describe, premising, however, that before he uses it, wetting it with water must be done, so that the ink may be equally laid on its surface.

THE PRINTER.

Perhaps the most astonishing and useful invention ever made is that of Printing. By its means we are enabled to diffuse knowledge of any kind, and in any language. The discoveries of science, the boundless stores of literature, and the beauties of poetry, are thus made the common property of mankind at large.

The present state of the printing business has not been arrived at suddenly. It has rather resulted from the perseverance and intelligence which has been devoted to it for four centuries. Indeed, the different branches of trade which contribute to the process of printing and book-making are much more numerous than many persons would at first sight imagine. We find that the miner, the collier, the metal merchant, the founder, the machinist, the paper-maker, and many others, each contribute their labour for the production of the smallest amount of printed matter; and when we consider the enormous machines employed in printing daily newspapers, we may gain some idea of the importance of the art in our own times.

But we will now say a few words respecting the history of the art. There is scarcely a doubt that those ingenious people, the Chinese, were the first to use blocks for producing impressions on paper, and they have possessed this art, together with that of making paper, for at least two thousand years. This process seems to have been first used in Europe about the middle of the fifteenth century. About the year 1440, Guttenberg, of Strasburg, commenced printing from blocks, and afterwards became partner with a person named Faust, or Faustus. They succeeded in producing printed sheets, and eventually, in 1450, published an edition of the Bible. Like most other benefactors of the human race, they met with no reward. The novelty of their invention, and its surprising nature, rather drew down on them the derision of the vulgar; so powerfully do ignorance and superstition act on the minds of the common people.

The art of Printing first became known in England about the year 1470, and William Caxton is said to have been the first person who printed books in our country. This, however, has been a subject of considerable dispute and uncertainty. Caxton set up his press in Westminster Abbey, and he was the first to print with *moulded metal* types. These, however, were what are called "black letter," from their size and the depth of colour they produced. The Roman characters were not introduced for many years afterwards into general use in England.

From the times of Caxton the process of printing gradually progressed, but certainly in no very rapid manner, as less than 4,000 books were printed in fourteen years, and the number of copies of each was very small.

Earl Stanhope assisted very materially in aiding the diffusion of printed matter, by the invention of the press which bears his name. This was first used about the close of the last century. Eventually the steam-engine was called to labour in place of human industry, and, of course, produced a wonderful revolution in the whole trade. But a few years ago, the morning papers could be turned off at the rate of only a few thousands per day; at the present time some of the newspaper offices publish their journals at the rate of 40,000 per hour,—each paper containing as much matter as a large-sized octavo volume.

Having thus glanced at the history of the art of printing, we must now refer to its practice. To do this in a familiar manner, we shall trace the progress of the manuscript for this book from our own hands to those of our readers.

We have been careful to write on *one side* of the paper only, as this facilitates the subsequent duties of those who have to print from it, in a variety of ways to which we shall not refer. Our manuscript is technically termed "copy."

This copy is placed in the hands of the "Compositor," as the person is styled who puts the types together. The types, the making of which we described at page 381, are long, square-sided pieces of metal, each of which is of exactly the same height. In front of the compositor are two cases, the upper one containing the capital letters, and the lower one the small type. On seeing the first word of the copy, the compositor takes from the boxes before him each successive letter, and, passing from right to left, places them in the *composing-stick.* Between each word he places a low piece of metal, which maintains them at their proper distances, and prevents one running into another. When a line is complete, he places before it the *setting-rule*, which keeps the types of the second line from disturbing those preceding it. After a number of lines are thus made, they are placed in the *galley*, by means of which any number of lines are arranged beneath each other. For newspaper printing, many lines are thus enclosed, just as if an ordinary page of a book had another placed continuously beneath it. This plan is always adopted when it is uncertain what corrections or additions are to be made before the types are arranged to fill a page of the book which is to be printed.

The next process is to print off two or three impressions; one of which is kept by the "Reader" at the printing-office, whose business it is to correct the errors of the compositor. Another impression is sent to the Author, who makes any corrections he may think fit. These impressions are called "proofs," and they are again placed in the compositor's hands to correct.

By means of the *bodkin*, he removes any wrong letter, and afterwards replaces it with those marked at the margin of the proof, making every other alteration which may be required. After this has been done, the type is squared off into pages, and placed upon an iron table, called an *imposing-stone;* the pages are next enclosed within an iron frame, called a *chase;* the types are then gently levelled by the *planer* and *mallet*, and the pages are *locked-up* by means of wooden wedges called *quoins.* The pages, so arranged, are called a "form," and this is placed on the printing press.

The type, or form, is inked by means of "rollers," composed of a composition of glue and treacle. A damp sheet of paper is placed in one part of the press. It is then passed over the type, and pressed down on it. By this it receives the impression of the ink, which is thus transferred to its surface. The sheet is then removed, and another substituted in its place, and the process is repeated until a sufficient number of sheets is produced. These are then dried, and afterwards pressed between glazed cardboards by a Bramah's press, which has the effect of removing all marks which the type has left on the paper, and of giving the latter a glazed surface. If a book be in course of printing, the sheet has to be folded into pages, these are then stitched together, they are afterwards bound by the *Bookbinder*, and, at last, through the *Bookseller*, they reach the hands of our readers.

It will thus be seen how much care and trouble is required to produce a printed work. Few of our young readers ever reflect on this fact, but we will venture to say that, if they ever attempt to write a work, and attend to its progress through the press, they will value every book they afterwards read to a much greater extent than they had previously done; remembering the labour which such costs to all persons who have to be engaged on it.

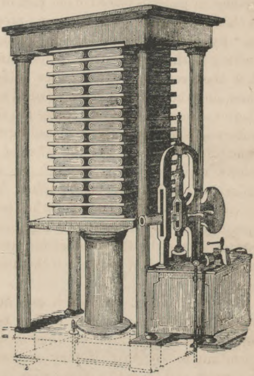

PLATE 32.—BRAMAH'S HYDRAULIC PRESS, p. 390.

[illegible]

When a book is finished very well [illegible]

[illegible]

[illegible]

The [illegible] of books is done [illegible]

STEREOTYPING.

When a book is likely to have a large sale a "stereotype" is taken of each page—in other words, a metal copy is made, which is used in place of the type. This is done by laying sheets of thin paper, damped and covered with a kind of paste, on the face of the type, and driving it into every part, by beating the paper with a hard brush. This forms a paper mould; and on fitting this into a kind of frame, and pouring into it a mixture of melted lead and antimony, a solid copy is obtained, in every respect identical with the original page of type. The latter is then "distributed"—that is, each letter is taken out of the form, and restored to its proper box in the *case* of the compositor, ready for use in setting up another page.

This plan saves the necessity of employing an immense amount of type, as, without it, each page would occupy type by itself; whilst by stereotyping, the same type may be used successively for any number of pages.

THE ENGRAVER.

The illustration of books is done by the Engraver, who produces woodcuts, copper or steel plates, according to the purpose for which these are intended.

Woodcuts are made thus:—The design is first sketched on paper, so as to guide the artist. He then takes a piece of boxwood, made perfectly level, and either sketches the design on the wood, which is first rubbed with chalk, or, if possible, transfers the design by means of the printing press from a printed copy, when such can be had. By means of sharp steel knives or tools he removes all those parts that are to appear light when printed; for in woodcuts it is the *raised parts* that print, just, in fact, like common type. The cut is then handed to the compositor, who inserts it into the page as if it were type.

Copper and Steel Engraving is done in a very different manner. In these methods the design is traced on the surface of the metal, either by the graver, a hard steel tool which cuts away a portion of the metal, or else the plate is covered with a varnish, to which a pencil drawing of the design is transferred by pressure. This forms a guide to the engraver, who removes the varnish by means of a tool at those parts which are to appear dark in the picture. The plate is then exposed to the action of nitric acid or aqua-fortis, which "bites" into the metal. In other words, it removes a portion, after which the composition is removed by washing the plate with turpentine, and the engraver then deepens some lines with the tool, and removes others by the burnisher. The plate is now ready for the printer, who fills all the *hollows* with ink, and perfectly cleans the surface of the plate. He then places a damp sheet of paper on its surface, and passing both through the press, the ink is transferred from the hollows in the plate to the paper; and thus a steel or copper-plate engraving is produced. This style of engraving is, therefore, exactly the opposite of wood engraving, which prints, as we have shown, from the raised surface only.

THE LITHOGRAPHER.

The method of lithography, or printing from stone, is comparatively a new invention. It is largely used for printing circulars, autographs, designs, and drawings; and depends on the fact that the stone used will only print from a surface which has greasy matter on it. It is as follows:—

In the first place, the writing is done on a piece of paper which has been well gummed; and this kind of paper is specially prepared for the use of lithographers, and called "transfer paper." The ink used contains soap and lamp-black; and it is the soap transferred to the stone that affords the printing surface.

This paper, after being damped, is then placed, face downwards, on the prepared stone, which has been first carefully cleaned and slightly warmed. The paper and stone are then run through a press, when the ink is transferred to the surface of the stone. The latter is then dried, and afterwards covered with a solution of gum. When this is dry, it is washed off, and an inked printer's roller (see page 390) is run over the writing, by which a layer of ink is transferred, *but only to the writing*, and no other part of the stone. A little acid is washed over this, and it is now ready for printing.

The paper to be printed is first damped, and nearly dried. The stone is then to be damped with a sponge, inked, and the paper is next laid on its surface. The whole is passed through a press, and a litho-printed page is produced. By again moistening the stone, and inking it, each time proceeding also as before, any number of copies may be printed off. When the stone is done with, it is inked over, and covered with gum water, and is thus ready for use at any time.

A modification of this process has been applied to what is called "nature printing," or printing copies of natural objects, such as leaves of trees, ferns, flowers, &c. And a very pretty process it is. Our young friends may procure a press, stone, &c., for the purpose, at a very cheap rate, and obtain a source of pleasing occupation.

Chromo-lithography is similarly followed, only many colours are employed instead of the common black ink. By this means the richly-coloured plates in many books are produced, and, when well done, they rival oil painting.

THE END.

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The Book of Trades